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SOUND PEDAGOGY.

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Teachers are courageous, else they would be unwilling to continue in an occupation so generally criticized. Possibly they renew their strength for continued effort in the consciousness that no learned profession escapes censure—not even those highly specialized—like medicine and law. The layman has positive views on the lack of medical knowledge adequate to cope with the ravages of diseases familiar in human experience for hundreds of years. According to the layman, medicine is conspicuous for its failures. The legal profession is often regarded as unreliable and as dependent upon tricks and chicanery. Possibly, teachers have become somewhat callous to criticism, through its constant presence. There are times, however, when the entire educational scheme is called in question. Observe I use the term *educational scheme* rather than educational system; for not a few thoughtful people question whether education has ever deserved to be dignified as a system. Those extremists remind one of the Irishman and the railroad from which he was discharged. It is reported that he remarked to an acquaintance, as they looked upon the printed words "Frisco System," "Frisco System, indeed; the road doesn't go within a thousand miles of Frisco and it never had such a thing as a system connected with it."

The present is witnessing a struggle for supremacy between those who would primarily hold to the past, and those who primarily would discard the past in order to welcome radical changes. There have always been the ultra-conservative and the ultra-progressive camps in education. The war between the theoretical, commonly called cultural, and the practical grows in-

[1]Address delivered at a meeting of the Central Association of Sciences and Mathematics, St. Louis, November 25, 1921.

tense, or wanes from period to period; but there is never a time when between the two a battle is not on. The contending forces are usually so evenly balanced as to keep the interest alive and to preserve to a degree both types of education. This is neither a new nor even a modern situation. If one reviews the history of education, he realizes the truth contained in the Biblical statement, "There is no new thing under the sun." At Athens there flourished for eight hundred years the world's most renowned seats of learning of the early Christian era. Even then and throughout most of that period discussion, occasionally acrimonious in character, separated those who predicted the collapse of education because of the cultural subjects from those who, with equal positiveness, foresaw the doom of intellectuality by reason of the attempt to limit the range of educational subjects to preparation for life's work. One might risk the assertion that the only distinctively modern contribution is that phase of training called vocational, a catch-word which spells financial returns to its devotees.

For many centuries the young have gathered in small and large groups to receive instruction. At first glance it might seem reasonable to expect that this long experience would have resulted in a prescribed course of studies, or at least in prescribed groups of courses of study which would discipline and inform to an approximate standard. Certain countries have proceeded upon that principle—a scholar in China is a person whose mental horizon is definable, and his accumulated knowledge can to a degree at least be classified and evaluated. Upon the other hand, however, most countries, even the advanced, have failed to find a system of training which could guarantee to produce results capable of being measured and weighed.

There are two factors to be reckoned with in solving educational problems: one, the human brain; the other, environment. How much the human brain has changed in the last two or three thousand years, I am not enough of a brain specialist to determine. I doubt whether there is an appreciable difference between the brain of a Greek of Demosthenes' day and that of an Englishman of Lloyd George's day. Individual instances of wonderfully endowed men are to be found in both ages, and among people as different in civilizations as American and African; but it is not clear that the human brain has materially changed, speaking for the average, in many generations. If such is the case, then one of the two factors is practically fixed. One might

therefore, suppose that one uncertainty was removed in dealing with educational problems. This would be the fact and then there would be left only the environment to be considered, were it not unfortunately true that thus far it has not been possible to demonstrate the precise mental food and the specific method of presenting it which will be most effective in starting brain activity.

The other factor vitally involved in educational efforts is environment. Until recent years a Chinese would have been helpless with only an American education, and an American would have had about as much chance to use his American education in China as would a head porter of a European hotel to use his six or more languages when alone on a mid-sea island. In other words, were the human brains exactly similar, wherever found, environment alone would necessitate education for use along lines quite dissimilar, and by *use* I mean not necessarily as a means of gaining a livelihood, but as an agency for the enjoyment of life whether at work or in isolated meditation. The glorious coloring of even an Italian sunset conveys no sense of enjoyment to the man who lacks sight. In other words, the subjects of education must inevitably vary widely as they are to be applied to different races of men and to countries wholly unlike.

For the same reason, too, lines of study will be relatively important or unimportant among the same race of men as circumstances change. What is eminently desirable as a subject of study for one generation and for one set of environments may be ill adapted to another generation and another set of environments.

To sum up the matter: so far as my experience, my observation and my reading have led me, I have not been able to convince myself but that the accusations will continue against those who practice teaching, since teachers inevitably use imperfect instruments; but their critics insist that only perfect instruments are justifiable in dealing with a matter so vital as a human being's mental welfare.

But, again, in a place like America, with a race of mixed blood (it is true) but facing essentially the same great problems of existence and living in substantially the same surroundings, cannot educators agree upon studies which will constitute the right sort of training? If required to answer categorically, I should say *no*. To come back to our original statement, personal choice, public opinion and local conditions combine to create insur-

mountable obstacles, even could experts agree; and the experts cannot agree on lines of study so long as they disagree on results to be secured. The cultural enthusiast will refuse to train with him who emphasizes the practical. Moreover, there is no real agreement, except along the most general lines, among the adherents of each of the disputants. The culturists are hopelessly divided, from those who decline to accept anything as an equal substitute for Greek to those who would confine the study of language to one modern tongue.

The term *cultural studies* no longer conveys its earlier meaning. It would be amusing, were it not so serious, to see the interpretation put upon this term by responsible heads of professional schools, as they claim to prefer that candidates for professional degrees should previously have taken a cultural course of two or more years in college. This sounds like a desire on their part to have prospective doctors, lawyers and dentists well grounded in that group of studies which, for several generations, was considered almost necessary for one who would stand in the community for acquaintance with literature, philosophy and the fine arts. It is quite common for these heads of professional schools to outline this "cultural" course of two or more years, which their prospective candidates are urged or required to take while in college. A review of a large number of such outlined courses shows one that, in most instances, these so-called cultural subjects are subjects directly leading up to the special training in the professional schools for which the students are preparing. In other words, in the opinion of these subsequent instructors, cultural studies are such studies and, in general, only such as bear directly upon a candidate's subsequent career as a professional man. A future specialist is required to narrow himself to his special line, even while in college. One wonders whether the real reason for this demand on the part of professional schools is the desire, perhaps unconscious on their part, of relieving themselves from the drudgery of elementary teaching, since teachers interested in research and advanced instruction naturally prefer to find their students adequately prepared.

But how about the cultural studies? Do studies along any line become cultural as soon as they are pursued with a view to a definite purpose in relation to subsequent courses of study?

But if culturists are divided, the so-called practicals are not. With them the solitary question is, can you use it? If one can answer that question in the affirmative, he is encouraged to pur-

sue the subject, especially if it can be shown that immediate results are certain. Make up your mind early how you are to earn your living, and select your courses of study with that primarily in view, and you are showing the wisdom of the far-seeing bread-winner.

In the haste to secure the practical, much illy digested food is placed before children and even adults as courses of study. Were it possible to follow the example of the two greatest teachers of history—Socrates among the Athenians and Jesus among the Jews—that is, to deal with a single individual or at most with a small group and that throughout the day's entire experience, so much would not depend upon the subject; for under those circumstances there can be exchange of views, shifting from one position to another, adjustment of difficulties by elimination and combination, correction of method of treatment, change of statement, withdrawal or modification of claims, and in brief the thousand and one ways of clarifying any position. Under such conditions the teacher feels his way and can adapt the contents of his theme to the mental peculiarities of his student. In fact, no more perfect illustration of the efficacy of such instruction can be found than in the case of the two greatest of all teachers, to whom reference has been made. In the very nature of the thing, however, such opportunities for instruction under constant companionship are so rare as to play but a small part in education as a whole.

The crying evil of much which now goes under the name of education is the fact that almost every conceivable occupation is taken as furnishing a basis for intellectual training, or rather for fitting the boy or girl, or young man or woman to make a livelihood. Manicuring, for instance, is a perfectly proper occupation, but that it and subjects equally trifling should be dignified with the name of courses of study is absurd. Yet in not a few schools such subjects are ranked as on an equality with others of established merit.

What, in brief, is expected from courses of study efficiently taught? What may one reasonably look for as a result of his schooling? The schools should teach one to think. That means to concentrate one's mind upon anything presented to it. The schools should teach one to be accurate, for certainly accuracy and power of concentration are vital to constructive work of any nature in any field, as one goes through life. What will be most likely to give one these two desirable adjuncts to a profitable life?

My reply is, those courses of study whose content embraces material which has been classified, organized and co-ordinated and, if possible, tested by experience. Among such studies are certainly mathematics and the sciences. These subjects fulfill to a great degree all the essentials to thought. The material is vast in quantity, thoroughly organized, graded, systematized to a nicety, and tested by experience world-wide in scope and (in the case of one of the subjects, at least) through centuries of actual practice in class room and lecture hall. One would be slow to assert that other subjects are not valuable; in fact, in certain instances other subjects are more valuable, but to put on a par with these foundations of education the popular treatment of subjects temporarily prominent is to lose sight of a vital principle in intellectual training.

It is hard to conceive in these days of a man intellectually trained who has omitted either of these two great topics, both of which call out the closest possible analysis of thought, concentration of thought, and effort to reach a definite result. It is to be regretted that, in the endeavor to attract the masses to even higher education, there should be withdrawn from the requirements considerable attention to these fundamentals. There is no intention to under-estimate the value of other subjects just as worthy of consideration; but my intention is to insist upon the fact that, if it is necessary to emphasize in modern education the multitude of get-rich-quick subjects and methods, they should in no case be put on a par with those subjects which I am endeavoring to emphasize. Certainly a man can scarcely be considered to be a thoroughly, a broadly educated man who has not had a considerable training in mathematics and sciences.

CLASS EXERCISE TYPES IN HIGH SCHOOL MATHEMATICS, WITH NORMS FOR JUDGING THEM. II.

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In the June issue of this journal twelve different types of class exercise, corresponding to as many different types of thinking in mathematical study, were listed and briefly described. Norms for judging six of the types of exercise were there given. This paper will complete the discussion by specifying and briefly describing the remaining six types, giving appropriate norms for judging them with considerable objectivity.

The six types treated on pages 535-540 of Volume XXI, No. 6, were: the conceptual, the expression, the associational, the assimilation, the review, and the drill types. These six types are, perhaps, the ones most frequently met in class-room visitation.

The six types remaining to be treated are: the problem, the topic, the application, the test, the research, and the appreciation types.

It is not claimed that the order of treatment given here is the order of their importance in teaching. It is, however, believed that the types enumerated fairly well cover the ground of the mathematical types of thinking that at one time or another, deserve to rise to the significance of characterizing entire class exercises. Moreover, the sort of thing done in a class period that features any one of the types is sufficiently different from what is most distinctive in judging other types to make the need for special criteria desirable.

One of the means good high school teaching today employs to meet the need of recognizing individual differences in pupils is the variation of type of class exercise from one to another of the foregoing types. To ignore distinctions as to kinds of mental activity being employed, by making all exercises alike in objectives, aims and procedures, is to become a routinist and a mechanizer. To know how a certain type of class exercise compares with good work of the same type is the important point in trying to obtain help for oneself by judging the work of others. The present discussion aims to be of some assistance in answering this question.

The Problem Type and Critical Norms.

In this type of class exercise a situation involving quantitative elements is being studied with the teaching view of motivating and impressing the import of the mathematical elements needed,

and with the learning view of understanding the situation and mastering the mathematical elements. The situation may be occupational, industrial, social, economic, scientific, or even mathematical, but through it the phase of mathematics to be learned comes as an episode in the comprehensive question which chains the interest and dominates the procedure. Whether the situation be choosing an occupation, finding the social or economic significance of a local factory, passing obstructions in a survey in progress, mapping to scale a complicated tract, learning the laws of freely falling bodies, determining trajectories, weighing on balances of unequal arms, discovering laws of force in machines, structures, etc., always a considerable part of the problem before the class is the mathematical phase of it. The dilemma is created by the situation, the mathematical study is to dispel the dilemma and bring certainty. This type of exercise is coming more and more into function as teachers acquire the technic of the problem and project methods of teaching. Some of the most significant improvements in teaching that have recently been made have come out of attempts to introduce the problem type of mathematical study. So far from reducing interest in mathematical study itself, it has been found to stimulate and foster mathematical interest.

Criteria for appraising the quality of such work are the following:

1. Was the class exercise really of the problem or of the topic type?
2. Was there a real situation calling for mathematics in the mind of the pupils, or was the situation merely a teacher-problem?
3. Was a real dilemma created by the situation? Illustrate.
4. Had the problem been well thought through and formulated by the teacher?
5. Was the problem kept clearly before the pupils by frequent reference to it?
6. Were suggestions from pupils encouraged for procedures as well as for matters of fact?
7. Were pupils' suggestions carefully evaluated and critized by the pupils?
8. Were any references to scientific literature used? How used?
9. Was work done at a pace such that pupils were required to think before answering?
10. Was the discussing kept well organized along definite lines, perhaps by blackboard outlines?
11. Was the mathematical problem really solved by the class?
12. Was too much or too little time used to attain the desired end?

The Topic Type and Critical Norms.

Many secondary teachers of mathematics still believe the topic, rather than a problem-situation, should be the impelling thing with high school pupils in mathematical study. Some teachers claim to be teaching by the problem-method who are, in fact,

using only the topic-method inasmuch as all the problems they employ are taken from the specific subject being taught. For example, the algebra teacher who motivates the fundamental operations, or factoring, or fractions, etc., through their use or necessity in mastering the equation, is employing not the problem but the topic type of procedure. All texts, for class use, that aim by the organization of their material to assist in any motivation at all, are arranged on the topic—not the problem idea. Naturally this topic plan reveals itself in class-room practice, for have not *Rugg* and *Clark* in their monograph on *Reconstruction of Ninth Grade Mathematics* shown conclusively that the real course of study in algebra is the adopted text, no matter what else may be pointed to as the course of study? This is probably even more the case with high school geometry than with algebra, though the evidence has not been so convincingly marshalled for geometry as *Rugg* and *Clark's* monograph has done it for algebra. As a matter of fact the topic type of class exercise is to be seen everywhere and critical norms for judging it will be more frequently needed than for any other type of developmental lesson in high school mathematics.

The writer submits the following as critical norms for the topic lesson:

1. Was the class exercise really of the topic type? Did it purport to be of the problem type? Illustrate.
2. Was the topic merely the next in the text, or was it more inclusive, involving the thing being taught as a necessary detail?
3. Did the topic furnish a real motive and reason for the thing being taught?
4. Was the class attentive and interested, or inattentive and languid?
5. Was there any life interest to pupils in general in the topic as used?
6. Was the topic kept before pupils as the impelling motive by frequent reference to it?
7. Was there any deviation from the adopted text made in the use of the topic?
8. Did the topic embrace the details of study in a manner to synoptize and unify the detail into an organized unit of thought?
9. Did the work move forward expeditiously? Illustrate.
10. Did pupils actually contribute suggestions of value? Illustrate.
11. Were pupils' suggestions attended to and critically evaluated?
12. What per cent of the class contributed suggestions? (Percentage of participation.)
13. What per cent of the class contributed suggestions of value? (Percentage of efficiency.)
14. Give the per cents of (a) participation, and (b) efficiency for the class.

The Application Type and Critical Norms.

It has long been recognized by good teachers that the proof of knowledge of a mathematical fact, precept, or principle, is neither the ability to recite it correctly nor to demonstrate it,

but is the ability to recognize and use it in an appropriate situation. No teaching technic is good that does not include the necessary element of teaching the application of the thing taught. The aim of mathematical pedagogy today is not knowledge alone, but usable knowledge. Perhaps one of the most acutely painful needs of current practical pedagogics in mathematics is a definite technic for teaching the application of mathematical knowledge. The long period, let us hope now happily closing, during which the main reliance of mathematical teaching has been upon mental discipline as an objective, has led us to see with *Minnick*[1] that practical skill, modes of effective technique, can be intelligently, non-mechanically used only when intelligence has played a part in their acquisition, and furthermore, that only those things, which have been learned in useful relationships, will surely be useful. Certainly, we are ready to admit that the best way to get from a subject the largest measure of whatever disciplinary value it has is to get from it the largest possible measure of its practical value. A condition precedent to success in teaching the application of knowledge, mathematical, as well as other sorts, is that the learner be moved in some way to form within himself the intent to master application. Teaching effort must continue to go awry until we learn how to work the will-change within the learner of getting him *definitely* to *determine to master* what he has hitherto not cared for because he felt no benefit of any consequence came of it.

It would certainly seem that whatever technic we do ultimately set up for teaching the application of mathematical knowledge must include such study of subject-matter as will enable the pupil to learn it in its useful surroundings. Our besetting sin is teaching subject-matter isolated from its natural settings and afterwards attempting to furnish through a few sample applications the much-vaunted knowledge and skill to apply what has been improperly taught in the first instance. Such teaching procedure can never lead to ability to apply knowledge. The environment of knowledge in the learning act must be more adequately attended to in our teaching technic if we are to succeed in teaching the application of knowledge.

Furthermore, the environment of the learning must contain a variety, a multiplicity of applications. To touch and deal with utility in as many phases and as continuously as possible is the only sure way in which the learner can be led to focus attention and to hold it, upon the problem of mastering application. Using

the ideas *during*, not *after*, the learning of the ideas is the only way out of the present "Slough of Despond" of mathematics teaching.

The following critical norms will aid in judging this type of class exercise:

1. Was the old time spirit of "let applications take care of themselves" manifest in the teaching?
2. Did pupils seem to care about applying what they were being taught?
3. Was there a manifest attempt to teach varied applications of knowledge?
4. Was subject-matter taught first and application afterwards?
5. What sort of environment was used in the teaching?
6. Was this environment within the comprehension of pupils?
7. Did pupils suggest any uses, new to them, of the knowledge gained?
8. Were the applications valuable and vital, or only perfunctory?
9. Did pupils seem to feel they were learning something worth while or was the attitude of '*What's the use*?' manifest?
10. Were the applications to present-day situations?
11. Suggest any applications not used in the class that you would have used.
12. Were the applications tedious, or complicated?
13. Were any specific instructions given as to how to apply the knowledge? Any needed?
14. Was the subject capable of much application by the pupils studying it?
15. How many different kinds of applications were shown?

The Test Type and Critical Norms.

Lessons of a test character and of the sort preparatory to the giving of standardized tests are coming to be a common occurrence. The tests may be given for diagnosis, for remedial effects, for measuring and comparing ability or attainment in a subject, or for practice effects. Recent texts for ninth grade mathematics and for first courses in algebra are beginning to include more or less test material, and to make the work on this material any great improvement on the old-fashioned written recitation and drill exercise certain conditions must be met.

In the first place, the pupil's state of mind regarding the test must be attended to. He must be made to feel that the test is more than anything else to let him see for himself how much he knows of the subject and how well he knows it. He must feel that he is merely showing himself to himself by the aid of standards that are as reliable and impersonal as they can be made. He must appreciate that if he works normally and vigorously he may, in a standardized test, get a reliable comparison of his achievement with that of many others of his own age and stage of advancement. He may thus have reliable standards of what

[1] J. H. MINNICK: *The Recitation in Mathematics*, Mathematics Teacher, March, 1921; pp. 119-123.

he is and ought to be expected to meet. He will thus come to the attack upon advance work with more courage and zest than he otherwise would.

The rightly conducted test lesson enables the pupil also to locate his weak points that he may concentrate on the precise things that he sees he needs to strengthen. This assistance to him in economizing his efforts to get on through the setting up before him of independent standards of attainment, the defining of clear objectives for him and the converging of study effort precisely where it is most needed are appreciated by the learner as real helps, provided the tests are well devised and rightly conducted. They reduce dependence on the teacher and furnish the pupil his own gauges of excellence and habits of self-criticism and self-guidance.

Criteria for judging the test type of class exercise are as follows:

1. Were the pupils properly prepared and equipped for the test?
2. Were they willing to undergo the test?
3. Were the initial conditions made natural by the giver of the test?
4. Did pupils show evidence of over-strain at the outset or subsequently?
5. Did the test seem a real test of what it purported to measure?
6. Was it a standardized test? For diagnosis, ability, achievement or practice?
7. Was the timing properly administered?
8. Did all the pupils work all the time?
9. Were pupils curious to know the results of the test?
10. Did pupils seem to accept the test as fair and legitimate?
11. How were the tests scored and by whom—teacher, pupil, or faculty?
12. Suggest any improvement on (1) the character of the test itself, or (2) the method of administering it.
13. Would you undertake anything similar in your classes?
14. Have you ever employed such tests and, if so, with what results?

The Research Type and Critical Norms.

Good teaching must always seek to produce or to enhance two types of ability, viz.: ability to *reproduce* knowledge after a longer or shorter period of partial disuse, and ability to *produce* knowledge, or ability to arrive at new knowledge on the basis of old knowledge. The second type is research ability. The form it may take in high school classes of mathematics is the ability to do work analogous to what has been learned, but involving new elements and phases. Many teachers rate the sort of class work that leads to productive ability very highly, and plan much of their teaching definitely to attain it. Some teachers would make a course in high school algebra or geometry a continuous training course in problem attack and solution, or theorem attack and proof. They would exalt "the original" in algebra and geometry

to the rank of central importance. They consider their real business to be to discover and foster the research attitude. This type of teacher, despite the heavy handicap he is now laboring under, is increasing and is destined still more to increase, as educators and school people generally come to believe in the significance of research.

Critical norms for a class exercise of the research type are the following:

1. Was there a real problem before the class?
2. Did the class really do the work, the teacher only guiding?
3. Was anything really new found out by the class?
4. Did the class, as a whole, seem to enjoy participation?
5. Did the class seem of even ability?
6. What per cent of the class participated in the original thinking?
7. Did any enthusiasm of discovery appear during the class exercise?
8. What was the teacher's method of keeping the attention focussed on the problem of the day?
9. Was the plan capable of being used by others, i. e., not too closely associated with the personality of the teacher?
10. Was a considerable part of the work real research for the class?
11. Suggest any ways you would vary the observed practice.
12. Give the per cents of participation and of efficiency of the class.

The Appreciation Type and Critical Norms.

In most school subjects excepting mathematics occasional class exercises are given in whole or in considerable part to getting pupils into an intelligent appreciation of the subject being or about to be studied. Why should this practice not be followed also for the mathematical subjects? May we not hope to see this type of class exercise become more frequent for mathematics as teachers learn the great value for high school work in mathematics of historical, industrial, and social material, and become more expert in the humanizing of mathematics? Appreciation of the value of mathematical attainment calls for a kind of ability that is much more widely distributed in the race than is the ability to become mathematically expert. To appreciate the contribution that mathematical skill and industry have made and are making to civilization is not only an inspiring preliminary to intensive mathematical study, it is also an element in sound culture in its own right. Many of the world's greatest thinkers have found stimulus and motive for high endeavor in this sort of study of mathematics. Surely we ought to give more systematic attention to mathematical appreciation in the teaching scheme than is customary. May it not be suspected that writers and speakers who voice their irritation at having the names of mathematicians attached to important theorems have not had much help

in school or elsewhere in getting a true appraisal of the worth to civilization of the performances of the men who bore those honored names? To most of us it seems a modest enough return for posterity to attach the discoverer's name to some important truth. Some of the appended names may not be musical to modern ears, but the worth of the services rendered by the bearers to subsequent investigation and discovery condones the want of harmony. Those who know the underlying facts see nothing offensive or in bad taste in Cartesian geometry, Tchirnhausen's transformation, or the theorems of Apollonius, Euler, Bernouilli, Newton, Wallis and a score or so others.

Underneath the movement for a greater use of the history of mathematics in the teaching of its several branches is the thought of emphasizing more the appreciation phase of mathematical learning. We have not yet gone as far as we ought in the use of historical and environmental backgrounds of mathematics but we are doing better year after year in the pedagogical evaluation in the history of mathematics. The teacher who will give one or two class exercises a month to mathematical appreciation will find the mathematical spirit of the school very markedly improved in a surprisingly short time. The next best thing to a knowledge of mathematics is the right appreciation of its services.

Criteria for judging an appreciation exercise are as follows:

1. What agencies were being used to furnish appreciation of mathematical culture?
2. Had enough mathematical information already been given to enable pupils to appreciate the role mathematics had played in the situation?
3. If history was used, how was it used?
4. If modern uses in industry were employed, what were they?
5. Did the class seem to be making more intelligent their appreciation of mathematical study?
6. Did there seem any lack of appreciation arising from ignorance of mathematical knowledge or technic?
7. Suggest any other means than those used, for aiding mathematical appreciation in a high school class.
8. Was the age of the pupils appropriate for the sort of thing being done?
9. Any difference between boys and girls in expressions of appreciation?
10. Would you favor using class exercises for appreciational work in mathematics?
11. Suggest ways of improving what you saw attempted.
12. Do you believe the time might better have been used in studying subject matter?

In concluding this discussion it may be said that professional expertness in the teaching of high school mathematics consists largely in first recognizing the type of thinking the particular

problem or topic calls for and then choosing the teaching technic that is most appropriate to the type of thinking in hand. This is real lesson-planning. An exercise in associational thinking should not be conducted in the same way as an appreciation, or a drill, or a problem-solving,or a concept-forming exercise should be conducted. Each type has its appropriate technic, and, in studying the teaching of others, the question is how does the particular sample exercise being judged compare with good work of its type? Because this is true it happens that some teachers are excellent in some class exercises and very poor in others. The point to be emphasized is that in both the planning and the judging of teaching discrimination of types of work is an essential condition to success. This is no less true because a given class exercise may exemplify two or more of the types above mentioned. Finally, real benefit from the observational study of the teaching of others comes largely, if not mainly from the comparative judging of types of mathematical thinking involved and of the degree of appropriateness of the class procedure to the type of thought.

REQUIRED MATHEMATICS IN THE FOUR YEAR HIGH SCHOOL.

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Algebra is Not a Suitable Required Subject.

Few men have argued that the present organization of high school mathematics is not the best for pupils who aim to take college work which requires considerable mathematics. An increasing number of public school administrators and mathematics teachers are, however, coming to the opinion that to require all pupils to study algebra is a mistake. If the high school is to be primarily a college preparatory school, then the present organization is justifiable. If the high school is the people's college, with the minor purpose of preparing a few of its pupils for higher education, then the first year of the present organization is clearly unjustifiable as required work.

On the other hand there has always been a general demand for more mathematics than is obtained in the first eight grades. This demand is responsible for the high school mathematics requirements. A few schools have removed all such requirements and many will probably follow their example unless the first year course is adapted to the purposes of the public high school.

The movement toward the reorganization of the high schoo mathematics courses is well under way and it is the purpose of this article to discuss the new required course.

Content of the New Required Course.

The consideration which should determine the content of the first course is its usefulness to the average first year pupil. The course should be practical, probably not entirely in the sense of bread and butter acquisition, but certainly it should not be an attempt to anticipate a pupil's school needs beyond the twelfth grade. In determining the content these questions should arise; first, "What will most of the pupils desire and need to know and do in the line of mathematics?"; second, "What is there in the field of mathematics which will best satisfy these needs that can be taught in a year?" Community interests and children's interest should be vital forces in determining the content.

A review of late texts on general mathematics for the ninth grade, of junior high school texts and of reports of committees on the reorganization of high school mathematics will show that the leaders of the movement are fairly well agreed as to the content of the first year course. It includes, briefly: Algebra, with emphasis upon the idea of relationship, the formula, variation and graphical representation of data; factual and constructive geometry, with emphasis upon congruent and similar figures and numerical trigonometry in the solution of right triangles by use of the sine, cosine, and tangent. In the matter of omissions from the course in algebra the recommendations of the National Committee on Mathematical Requirements are being generally followed. Portions of their recommendations follow. "Drill in algebraic manipulation should be limited to those processes and to the degree of complexity required for a thorough understanding of principles and for probable applications, either in common life or subsequent mathematics." "In addition to the large amount of drill in algebraic technique already referred to, the following topics should, in accordance with our basic principles, be excluded from the work of the first two years: Highest common factor and lowest common multiple, except the simplest cases involved in the addition of simple fractions; the theorems on proportion relating to alternation, inversion, composition and division; literal equations, except such as appear in common formulas, such as may be necessary in the derivation of formulas, the discussion of geometric facts, or to show how needless computation may be avoided: radicals, except as indicated in a

previous section; extraction of the square root of polynomials; cube root; theory of exponents; simultaneous equations in more than two unknowns; pairs of simultaneous quadratic equations; etc." The tendency seems to be away from attempting any demonstrative geometry whatever.

However, the first year course must not be characterized alone by the mere omission of certain topics but rather by a new treatment of the old topics. The content proper is children's needs met—let the degree of complexity, amount of drill and topics used fall where they will.

Order of Presentation of Topics.

While leaders are fairly well agreed as to the mathematical topics to be taught, they differ widely in the order and mode of presenting these topics. In the formal presentation the order is determined largely by the subject matter itself. Logical development is the prime requisite. In the general course the development should be psychological. The subject matter must be grouped around problems of the children with little concern as to whether it is algebra, geometry or trigonometry. The determination of the best problems to motivate or project the work will require much experimentation. We want genuine children's interests and adults cannot casually assume them. While the present divergence of opinion indicates that we are still somewhat up in the air, it is a healthy sign and a prediction of a real accomplishment.

Our great failing is to become enthusiastic over a new idea and sacrifice its spirit to a superficial form. Just as the social recitation often degenerates into the usual recitation conducted by pupils, so is general mathematics apt to become a portion of algebra followed by a portion of geometry and so on. A mere stratification of algebra, geometry, and trigonometry is not as efficient, nor is it as satisfactory to the teacher or pupil as our present organization. Why? Because it is unquestionably a considerable satisfaction for many pupils to follow the logical development of algebra or geometry. There is satisfaction in having completed a well rounded task. In a stratified course the class has no sooner acquired an interest or momentum in algebra than there is an abrupt change to geometry with different problems and different ways of thinking. The teacher gets a sort of jerky sensation and the pupils seem to be continually in hot water, never knowing where they are or what it is all about. If mathematics is to be taught in stratas, it is not advisable to de-

vote less than about one-half of a school year to a subject. Our hope to make general mathematics a living, active subject depends upon our ability to take the methods of algebra, geometry, and trigonometry out of their several shells and apply them to the solutions of problems which may be made real to children.

Teachers and General Mathematics.

Before a large measure of success can be obtained teachers must be trained to teach the new course. There is no subject in the high school course of study as easy to teach as algebra, with the aid of one of the standard texts. Teachers have learned mathematics in the logical way and it is natural for them to teach mathematics in the same way. Any one of the present texts in reorganized mathematics, if used by a teacher who is accustomed to the use of texts in algebra and geometry, is apt to be reported a failure. Things won't run smoothly; the exercises aren't carefully graded; the material is poorly organized; and they just don't like it. Before a teacher passes judgment upon a general mathematics text she must review her aim and ideal in teaching and look carefully to her measures of value; subordinate some values and exalt others. The late texts in algebra and geometry are nearly perfect for their purpose. There have been so many authors and so many revised editions that the finished product is good. Texts in reorganized courses must go through the same careful development. The fact that there are imperfections in them now should not reflect against the advisability of the general mathematics course.

What the course needs now is a more critical attitude on the part of administrators and teachers. It needs thoughtful criticism and not passive adoption or rejection. High school mathematics teachers, on the whole, are well prepared to deal with the problems of organizing a first year course for themselves. Present texts and the reports of committees on the subject will give the foundation and show the proper bounds for individual experimentation. Many teachers must add good ideas to the common fund, before excellent texts can be produced. A distinguished professor of educational philosophy is credited with saying that he wished that every high school text-book might be built to last just one year, then go to pieces like the one-horse shay. If that were the case, perhaps we teachers would give up being such textbook addicts, would profit better by our mistakes and develop better judgment and greater initiative.

Administrative Difficulties.

At this stage in the development of the reorganized courses some of the larger high schools are offering both the formal and reorganized courses and are advising general mathematics for those pupiil who do not intend to take more than the required mathematics. Administrators in the smaller high schools are noting this practice and are delaying their acceptance of general mathematics because they cannot offer both the formal and reorganized courses. But it would seem clear, if we desire to live up to the aim of the high school, that the reorganized course must replace the formal course in the first year in the small high schools. Provision for the general course should be made first, then, if possible and desirable, provision may be made for the formal course. The advisability of permitting electives in the first year is questionable because so many freshmen choose algebra who will never continue the study of mathematics. Freshmen have very little basis on which to make a wise choice. Then, too, this practice of the larger school probably indicates that they are cautiously approaching the adoption of general mathematics and does not necessarily imply their recommendation of paralleling the two courses.

Since the National Committee on Mathematical Requirements has taken its stand in favor of the reorganized courses, there will probably be no difficulty in getting colleges to accept such high school credit. Why is it that general mathematics cannot bear the same relation to algebra and geometry, etc., that general science bears to physics and chemistry? Such an organization seems to me to be the most reasonable, as well as the most obvious. A course in algebra given in the second year could be based on the algebra learned in the general course and about one and one-half year's work, as reckoned in the formal course, completed. The third year could well be devoted to plane and solid geometry or to plane geometry and trigonometry. There probably would be no objection to the certification of credit earned in the reorganized course, as its equal in the older organization. I believe that the difficulty of administering the new course is being overestimated.

It is certain that as a required subject general mathematics is better than algebra. It is probable that such a course will bring more pupils to the study of advanced mathematics and hence benefit the professional as well as the layman.

AN EXPERIMENT IN THE USE OF THREE DIFFERENT METHODS OF TEACHING IN THE CLASS ROOM.

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(*Continued from December.*)

Tentative Conclusion—Experiment I.

That for immediate retention and for development of power the developmental method stands first, the lecture method second and the text book method third.

The experimental series just completed gives only one aspect of the results of learning. In order to obtain any effective notion of the value of these above methods from the standpoint of pedagogy, it would be necessary to give a series of repetition tests after varying periods of time in order to see which method was best for retention on the part of the pupil.

A single suggested type experiment follows, which was not of great value because of the abbreviated form which was used and because of the nearness of repetition. It will serve, however, as a comparison with the method of Mayman, and will also give a slight index on the value of the methods used in retention on the part of the pupils.

One week after the series ended, or on the 27th of January, 1916, the writer repeated the last ten-minute test given in the test series. The day was mild and clear, humidity rather high, ventilation excellent, some windows open, the temperature of the room during the three tests averaged at 70. The writer explained to each class the purpose of the test, which was given during the first ten minutes of the period. Each class took the test in a businesslike manner, but class 122 seemed to work with more evidence of the knowledge than either of the other two classes.

The subject matter of the test, which was identical with the third test of the series, had been taught to class 107 by the text book method, to class 122 by the developmental method and to class 147 by the lecture method. The test papers, with those of the other tests of the previous series, were not marked until after two months had elapsed.

Of most interest is the comparison of the average percentage obtained in the original and in the repeated test by each of the classes, as this not only shows us which methods of learning

show out best in the original and repeated test, but also shows the comparative loss shown by each of the three methods after one week. These figures, of course, are of little actual value as only the one set is available, but they are certainly suggestive. The results do not bear out the work of Pyle[11] on retention for he says, "An immediate memory test probably gives fair index of permanent retention." Here the method giving the best immediate results does not give as good retention results as another method.

	Original Test January 19, 1916.		Repeated Test January 26, 1916.		Loss
Class Method		Class Method			
147 Lecture	Total 71.10%	147 Lecture	Total	68.64%	2.46%
	Memory 80.34%		Memory	78.39%	1.95%
	Power 64.94%		Power	62.14%	2.80%
107 Textbook	Total 77.30%	107	Total	70.86%	6.44%
	Memory 86.92%		Memory	77.17%	9.75%
	Power 71.23%		Power	66.66%	4.57%
122 Development	Total 79.60%	122	Total	74.87%	4.73%
	Memory 88.28%		Memory	85.63%	2.65%
	Power 73.81%		Power	67.70%	6.11%

Conclusion.

If it is safe to draw tentative conclusions from a single test series (which I doubt), we can say that:

(1) The developmental method again proves its superiority over the lecture and textbook methods with three first places, class 122 showing a total; a memory total and a power total higher than either of the other two methods.

(2) In the loss on recall the lecture method (class 147) came out ahead in all three totals with the developmental method second and the textbook method third.

These tentative conclusions show the necessity of a series of test experiments rather than a single set because of the possibility of unequal mental division of the classes. As a matter of fact, study of the comparative records of the classes during the first and second test series indicate class 147 to be of lower mental equipment than either class 107 or 122. Class 107 seems to be slightly superior to 122 and much better than 147. It would, therefore, be necessary for us to compare a much larger number of test series before we allow a final conclusion of scientific worth to be drawn. So far as we can say anything

[11]Pyle, H. E., "Retention as Related to Repetition," *Journal of Educational Psychology*, 1911, p. 320.

from this experimental series, we can demonstrate the marked superiority of the developmental method over either the lecture or the textbook methods.

The Factor of the Personal Equation in Such a Series of Experiments.

After watching the work of the teachers in the department of biology for a number of years, the writer has been forced to the conclusion that a given method which to one teacher may be of very great value, may on the other hand lose much of its value in the hands of another teacher, especially if that teacher believes that he may be using a method which is better. In a large department (19 teachers of biology) such as the writer supervised, the individuality of the teacher plays an important part in the aggressive work of the department. Different types of mind of necessity mean different methods of work. Several of the teachers, however, showed a willingness to participate in a series of experiments with the writer in order that he might make some comparison of the factor of the personal equation in a given series. Three teachers whom the writer has designated as Mr. A, Mr. B and Mr. C, took part in the experiments, each teacher making a test series of three sets of papers with three equal groups on three successive days. The writer is unable to report fully upon these series of experiments because of the loss of the papers of one of the series by Mr. A, and because both Mr. B and Mr. C hoped to continue their experimental work.

Mr. A was an extremely good teacher. His personality was most pleasing, and he was a favorite with both pupils and teachers. His method was of the development lecture type. He consciously strove for problem solving in the class room. The writer looked upon him as one of the strongest teachers in the department. In an experimental series with the same three classes with which the writer worked he came to the same conclusions as did the writer, using the same three methods. He also found the developmental method showed most strongly in the solution of power questions.

A second teacher, Mr. B, was an excellent teacher also, although he sometimes allowed his classroom to become a lecture hall. He had for some time past done outside work in an evening "cram" school, where it becomes necessary to inject as much interesting subject matter into an hour as is possible.

His informational lessons were models and he made his boys think as well by means of informal questions which were introduced into his lecture lesson. He was considered by the writer as one of the ablest informal lecturers we had, and for that reason an experimental series was suggested for him. The experiment was performed with second term classes, i. e., boys who had already taken one term of biology. During the actual working out of the series the writer was in his room on several occasions and noticed that his lecture lessons were much better given and much more logical and interesting than his developmental lesson. When this fact was suggested to him, he had no idea that this was so. Unfortunately the sets of questions suggested for the three tests did not reach him in time to give to his pupils so that he made out his own questions, which did not differentiate between memory and power on the part of the pupil, but otherwise were excellent.

His graphs showed that the lecture method gave better results than did the developmental method and decidedly better than the textbook method. In view of the writer's observations of Mr. B's teaching, and remembering also that both Mr. A and the writer were slightly prejudiced in favor of the developmental method, these figures are, indeed, interesting as showing how, despite our best efforts to safeguard an experiment, the personal equation is bound to play an important part. In the writer's own case he consciously tried his best to make the lecture lesson cover exactly the same points as did the developmental lesson, both of the lessons being based upon certain chapters in the text which was used. He has no doubt that Mr. B tried in the same way to make the two different methods of teaching even. But, nevertheless, subconsciously, perhaps, Mr. B taught the lecture lesson a little more efficiently, probably because he had by constant practice perfected himself in this method of teaching.

A third teacher, Mr. C, was an enthusiastic young man, who although somewhat slow in his reactions, yet always consciously taught for thought processes. He was always on the alert to push home an idea, rather than a fact and made his classroom a place for the interchange of ideas. His experimental series was carried on with three nearly equal first term classes. His work, which was not yet ready for publication, showed conclusions somewhat similar to the writer's. It was hoped by the writer, that he might have both of the above publish their

results a little later when they had made a sufficient number of experiments to be worth while for use in obtaining valid conclusions.

EXPERIMENT. SERIES II.

An Attempt to Determine the Relative Value of Visual and Oral Instruction in Demonstration or Experimental Work in Elementary Biology.

Subjects: For this purpose two classes in the first term of the DeWitt Clinton High School were used. The classes had elected Spanish as their language. They were of poor average mentality, being rated as B classes by the elementary schools from which they came. Class 108 had 31 pupils, class 127 had 26 to 28 pupils present on the days when the experimental work was conducted.

Material Used: The classes were put through the test exercises during a succession of days during the first term at a time when the laboratory work was devoted to tests for food substances, the digestion of insoluble foods in growing seedlings, the work of the root in digestion and absorption of insoluble mineral salts.

Methods Used: In general the following was the method of procedure. The class was taught by the given method and allowed to make notes and write up as much of the experiment as possible at the time of the demonstration. The test examination was given during the first ten minutes of the period on the following day.

Description of Experimental Series.

First parallel experiment was made on February 26, 1917.

Subject matter: To prove the presence of protein in an unknown substance. Class 108 was taught by the visual method. The day was clear; room 65°; humidity low. In making the test and the experiment which followed, the teacher carefully avoided all oral work. Names and scientific terms were written on the board and only such directions as were absolutely necessary were given. After performing the test (*The Xanthroproteic*) for protein, the teacher then tested the unknown substance for the presence of protein. Paper was given out at the beginning of the period, but before the experiment could be written up the bell rang for the close of the period. Boys were told to write up the experiment at home and bring it to school the next day.

Class 127 followed, the next period. The day was bright; temperature 68 ; humidity low. With this class the teacher developed the problem using the oral method of demonstration and in addition asked questions of nearly every member of the class in an attempt to make clear the steps of the experiment. Much interest was shown, the boys appearing to be active.

The next day, at the beginning of the class period, the following question was given out: Problem: To test an unknown substance for protein. The day was bright, moderate winds, considerable humidity; temperature of 65°. Class 108 (visual method) appeared rather "stumped" when they got the dictated question. Some looked intelligent and got to work at once while several boys attempted to copy. Still others gazed in vacancy, only half the class worked with any degree of earnestness. Papers were collected after 7 minutes.

Class 127 on the other hand appeared to make a strong attack on the question. Two or three boys did not get to work, but in most cases mental activity seemed high. The time (7 minutes) was occupied by most of those at work.

Results.

A glance at the table shows a rather surprising equality, the average percentage of class 127 being 58.1%, while the average percentage of class 108 is 62.3%. This is contrary to expectations as the mental activity of class 127 certainly seemed greater. The question given was a pure memory question, and it would have seemed likely that either method would give results. The individual result showed an almost equal number of high marks by the visual and oral methods, but more absolute failures under the visual method. This, however, may be due to the mentality of the pupils, or it may be due to the faulty method used in allowing class 108 to take their papers home to finish.

The second of this test series was given after a lapse of several days. The same two classes were used, and the same order of test methods were used,—class 127 using the oral method, and class 108 the visual method. The type of experiment used was much harder to comprehend as it involved a series of three different pieces of work, all of which had to be connected logically in drawing the conclusion. The series first consisted of a test with phenolphthalein solution to show the color reaction caused by acid and basic substances. The test showed that acids bleached out the color from the solution. The next step was

to show two test tubes each containing a nearly neutral but slightly basic solution of phenolphthalein. In one of the tubes was placed a growing bean seedling, the acid from the roots of which was sufficient after a few moments to change the color of the testing solution. The third step in the series was to show the effect of acid upon lime.

With class 127 which came after four periods of work, English, Spanish and two drawing periods, the experimental series was developed with an attempt to have the class formulate their own problems. The period was productive of mental activity on the part of the teacher and class, and the bell for the close of the recitation rang before the boys could copy the experiment.

Class 108 took the work after a program of Spanish, study, lunch. The above described experimental series was performed but so far as possible no oral work was done. The class observed the tests, and the experimental evidence, but no explanation was given and they were told to formulate their own problem. Most of the boys went to work with intense earnestness and worked quietly until after the bell rang for the close of the period. The class accomplished much more in actual laboratory work in the time given than did class 127, and at much less expense of energy to the teacher.

The following day, March 27, 1917, the test was given. The day was dry, clear and cool; room 68°, little humidity. Class 127 had previously studied Spanish, and had had lunch. The question given was the following: "Tell how the experiment with the phenolpthalein solution enables you to explain how the root takes in mineral material." A complete answer expected:

(1) Knowledge of fact that the "phenol" solution turned colorless in the presence of acid.
(2) That the roots give off an acid.
(3) That acid dissolves limestone.

Class 108 followed, under same room and atmospheric conditions. Its previous classes were English, mathematics, study, Spanish. Both classes went to work earnestly and seemingly with intelligence. But the results which follow show that class 127 with the oral method understood the problem much better and gave a much better account of themselves in almost every respect. The average mark of class 127 oral was 6.6, while that of 108, visual, was only 3.9.

After this test was given, each of the above classes was given a third experimental lesson. On this occasion the methods

used with the classes were reversed, class 127 now being taught by the visual method and class 108 by the oral method. The lesson for this day was a simple experiment to determine the amount of loss by weight of organic matter and water in soil. In developing the problems with class 127 the fact was brought out that not only organic matter was burned out but that water was passed out in the form of vapor. The demonstration took nearly 20 minutes to work out, aside from the discussion because of the length of the time required to burn the organic matter out of the soil. The soil was weighed before and after heating; the figures in grams being placed on the board. The pupils were required to formulate their own problem but discussion over a proper title ensued.

With class 108 no problem was formulated but the steps of the experiment were carefully done and each student was required to pass up to the teacher's desk and make careful observation with eye and nose of the burning material over the bunsen flame, both before the organic matter and water had been eliminated and after it had been passed off. As previously the visual experiment was much more economical in time and energy of the teacher.

On March 28 test questions were given on this experiment and a fourth experiment series was made with class 127 again taking the visual and 108 the oral method of presentation. The following question on the previous day's experiment was given: "Suppose you were a farmer. Tell exactly how you would go to work to determine the amount of organic matter in the soil of your farm." To receive perfect mark, the boy had to show that he understood the experiment as well as to know that water and organic material were passed off during the heating of the materials.

Class 127 took this question at 3 p. m. after the following program: Drawing, (double period), lunch, mathematics, Spanish. The day was clear and cool, with rather high winds. It clouded over while the test was in progress, but soon cleared. The class at once went to work with seeming interest and determination. Class 108 followed the last period of the day after having had study, English, Spanish, mathematics, physical training. The room windows were opened, and a short setting-up drill was given just prior to the test. The results of the question for the two classes follows on another page, class 127 receiving an average of 6.0, while class 108 received 6.2.

Following the test questions, the last of the series of experiments followed as has been mentioned above. This time an experiment was performed to show the relative power of different kinds of soil to hold water. Gravel, sand, poor soil, rich soil, and leaf mold were tested by pouring 100 cc. of water through 100 grams each of the different soils, noting the amount of water retained after ten minutes. The problem was, in each case, left for the class to formulate but the title of the experiment was discussed in the case of the class receiving oral instruction. In this test, as in previous tests, class 127 received visual instruction, and got over more ground than class 108, although in this experiment the time spent in writing up the experiment in the laboratory was more nearly equal than in any previous period.

On March 29 the following question was given to the two classes on this test: "Of what practical value to the farmer is the information gained from the experiment performed yesterday?"

Class 108 took the test early in the day after a gymnasium period. They were obviously a little boisterous, owing to the fact that they had been playing games, and did not settle down to the test at once. Class 127 took the test after a long program at the end of the school day. Their previous periods had been: Mathematics, English, lunch, Spanish, study. The windows were open prior to the test, and the class went through a setting-up drill. The tabular results show a margin for the oral over the visual method of presentation in the laboratory. A graph made from the combined statistics of the four test series, making up the experiment, shows a decided advantage for the boys having the oral method of instruction in the laboratory. This is exactly what we would expect: two avenues of approach are better than one. Leadership makes for solution of problems; grouping about by individuals leads nowhere, especially if the individual is of too low mental ability, or if he is young and untaught in the methods of problem solving.

Conclusions.

Several general conclusions might be drawn from a sufficiently long series of experiments such as the writer has outlined. Such conclusions as have been put down here are, of course, merely tentative, and of little value as scientific conclusions. Still they are indicative of something.

1. The first noticeable feature of the series was that where

the question asked after the 12-hour period is a pure memory question the difference in the attainments of the two classes is relatively less than when a question involving discrimination and comparison is asked. The one test of the series in which the visual method shows above the oral development is where a pure reproduction memory quesion is asked. In the second test of the series, involving a relatively difficult comparison and analysis the visual method fails badly.

2. A second conclusion not apparent from the study of the figures, but easily demonstrated from a study of the individual papers is that the boy of low mental equipment is helped much more by the developmental oral lesson than by the visual lesson. The bright boy needs less help and has the mental equipment to enable him to solve his problems without so much help as his less fortunate classmate needs.

3. The number of perfect answers is much higher by the developmental oral method than by the visual method.

EXPERIMENTAL SERIES III.

The Oral Method versus the Laboratory Manual in the Laboratory.

Another pedagogical problem which may easily be attacked by the comparative experiment is this:

"What is the relative value of oral questioning and the laboratory manual in the laboratory or experimental work?" Two decades ago witnessed the beginning of a deluge of laboratory manuals in this country. Ten years ago every well regulated course in biological science adhered strictly to the manual as a means of conducting the laboratory exercise, and it has only been of late that the manual has been relegated to the place of a legitimate aid to the teacher and pupil, but not something which did away with the teacher as a leader in laboratory questioning.

Description of Experiments.

For the purpose of experimentation, the two classes 108 and 127 were taken as subjects. A new and, to them, unknown laboratory manual, Hunter's *Laboratory Problems in Civic Biology*, was used. Two sets of exercises were tried simply with the idea of demonstrating a possible method for future trial. For the first comparative test class 108 was taught by the developmental laboratory method, and class 127 by the means of the laboratory manual. The two classes were tried out on the rather difficult complex concepts of the formation

and growth of an ear of corn, and the structure, external and internal, of the corn grain.

Class 127 came the first period in the morning. The day was overcast, damp and rainy. Room temperature 65°, humidity high. The material was provided for the class, and the new manuals, which never had been seen previously by the class, were given out, one to each boy. The lesson was introduced with a short oral discussion, and then the class was left to work out their own salvation with the material on the desks, and the manual in their hands. For ten or fifteen minutes the class wasted time, at a loss what to do. At my suggestion they read over the questions again, and at length most of the class got to work. The rest of the period, the teacher did little active work, and the class appeared to be working slowly.

Class 108 the next period were introduced to the lesson by means of an oral discussion, and the exact subject matter covered by the laboratory outline is taken up by means of oral discussion in the classroom. The class found the idea of the ear of corn a hard one to get, in spite of the demonstration material used. The class, however, was much more evidently interested in the work and showed signs of understanding the work given. But development goes slowly. The next day short identical tests were given to the two classes. The test questions were:

1. Explain how an ear of corn is formed.
2. Compare a corn grain with a bean seed, giving likeness and differences.

The difference in attack between 108 and 127 was very marked. The latter class almost as a unit hesitated and seemed at a loss how to proceed, while the other class got to work in a businesslike manner and showed that they at least knew something about the matter in hand.

On March 29, a second series was made. This time class 127 had the lesson by the oral development method while class 108 used the laboratory manual. The lesson was unlike the previous lesson based on two related topics, but these topics were formulated, both oral and in the laboratory manual, as two separate problems. The first dealt with the mineral consituents of inorganic soil, the second with the part played by bacteria in putting nitrogen in usable form into the soil. The difference in attack on the part of the two classes was even more marked than in the first test series. Class 108 came

into the room relatively fresh after a program of only one period in the gymnasium. The weather conditions were clear, humidity low, temperature 65°, air and light in room good, time allowed for learning 30 minutes. After the books had been given out and the method of work explained orally, the boys were left to themselves except for such individual help as was given as the teacher passed about the room, stopping at the desks of different pupils. The class took a long time to settle down to work, in spite of the full explanations at the beginning of the period. Several very foolish individual questions were asked which showed that some members of the class did not comprehend the printed instructions, and several boys attempted to get more light from their neighbors.

Class 127 took the work the last period of the day at a time when the fatigue curve must have been high. The day was still clear, humidity low, the class took a setting-up drill with the windows open, just before going to work so that the air and temperature were excellent for work. Time allowed for learning 30 minutes. In teaching this class the fatigue of the teacher was quite noticeable although that of the class was not so great. In the class discussion the amount of work covered during the 30-minute period was not as great as that covered by a few of the brighter boys of the class 108, but the average of work for the classes was nearly equal.

The following day, March 30, a rather easy test was given the two classes, based entirely on memory and observational work. The questions were:

1. Name five chemical elements taken out of inorganic soil by roots. (5)
2. (B) In what form are these elements taken into the roots? (1)
3. (C) Name two sources of nitrogen in soil. (4)

In (B) the teacher expected a perfect answer to be given, "soluble mineral compounds," otherwise 1 credit was deducted from the total of 10 credits for the entire question.

Both classes made a strong attack, but it soon became evident that 127 had more to say than 108. The comparative figures which follow show that not only did they have more to say, but they said it in a more accurate manner.

Developmental Method.

Although we had no perfect answers in either group, because of the difficulty of the second part of the question, still the relative difference is very great especially in the number of high marks received.

Conclusions.

1. Based on comparative marks the oral laboratory lesson was far superior to the laboratory manual lesson.

	0	1	2	3	4	5	6	7	8	9	10
Development	5	3	7	8	10	7	9	4	4	2	0
Laboratory Manual	6	10	10	9	10	5	4	1	0	0	0

2. Judged by the fatigue of the teacher the laboratory manual lesson was much easier in every way.

3. The five brightest boys showed motivation with the laboratory manual method, but the majority of the class work much more intelligently and with more interest under the developmental method.

GENERAL CONCLUSIONS.

1. That of the methods tried experimentally in the laboratory the oral problem development was best fitted to the needs of first year pupils in the high school.

2. That the oral development of the laboratory experiment produced better results than the visual method of experiment.

3. That the oral question and answer method in the laboratory was more productive of results than when a laboratory manual was used without oral discussion.

4. That in the above experiments the personal equation was a factor of very considerable importance. The personality of the teacher was sufficient to change the results of a given series of experiments. This question should be carefully tested in a large high school. That "power" as such can be tested by experiment we believe, but all attempts to analyze the ability of a group to answer "power" questions by means of uniform examinations marked by teachers in committee is of little value because of the personal equations of the various markers of the committee.

5. That this piece of work should in no sense be considered as final nor should any results of the experiments be considered as anything more than suggestion. Much more work must be done under laboratory conditions before any real conclusions may be validly drawn. But the suggestiveness of some of the findings makes it evident that careful investigations scientifically conducted will bear fruit well worthy of the time and energy spent on the investigation

SOME ASPECTS OF THE CULTURAL VALUE OF PHYSICS TEACHING.

By C. F. HAGENOW, Ph. D.

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It is with a sense of sincere appreciation of this opportunity to address co-workers in the field of physics teaching that I present the following for your consideration. You will soon see that I have nothing new, in principle, to offer. It is more a matter of a shifting of emphasis.

My purpose is merely to ask your attention for a few minutes to a phase of physics teaching that I have felt deserved more recognition than it has been receiving for a number of years. It might be called the cultural phase of the subject, or at least some aspects of that phase. Naturally much of what is said here applies equally well to other sciences, but you will agree with me that physics possesses certain advantages in the remarkable and unique opportunities it offers for accomplishing the purpose in view.

Some years ago a professor of Greek in my home-town university made the statement that the essence of culture, on the part of an individual, lay in his attitude toward the arts and sciences rather than in his actual attainments in them. I have always thought this a very happy way of expressing the truth of the matter. To put it rather broadly, a man may be cultured despite the fact that he has, let us say, a vanishingly small acquaintance with this or that art. Lack of opportunity, or perhaps even hereditary influences, may have rendered his capacity for acquaintance with, or even for appreciation of an art or science exceedingly meager. But his purely intellectual reaction to the significance of that art or science, his estimation of its value and its influence in the history of mankind, is the test that stamps him as cultured or not. Conversely, a certain detailed and technical knowledge of a subject does not guarantee a just appreciation of the subject as a whole and a proper perspective of its relation to other departments of human accomplishment. It is with a view of emphasizing the desirability of gaining more of this perspective in the teaching of physics that these remarks are made.

The term "cultural value of physics" has a suspiciously "by-product"-like sound, and yet I should like to make clear that, on the contrary, it is the teaching of physics *as* physics that I

[1]Read before the Physics section at the Soldan High School, St. Louis, Mo., November 25, 1921.

have in mind. As a friend of mind once expressed it: To make a business of securing happiness as an end is a sure method of failing to attain it; it comes of itself with right living and thinking. In that sense, perhaps, the benefits acquired from the study of physics might be termed "by-products."

The emphasis has so often been placed on those benefits having to do with the acquisition of the knowledge of physical laws the disciplinary value of the training (which is to be "carried over" to other activities of life), that there is danger of over-looking other very important and legitimate factors. These I can, perhaps, sum up by saying that they concern themselves with the student's proper appreciation of the methods, aims and accomplishments of physics and their bearing on other human activities. To obtain a little of this appreciation and a truer perspective is to acquire the attitude that denotes culture. It is none the less physics because more of the historical and human element is added. A better understanding of the historical setting, a more vivid realization of the significance of the subject in relation to the economic life of people will contribute elements that are almost certain to be retained long after many of the "useful facts" are forgotten. What better test of their educational value could one ask, granted the intrinsic worth of these elements? And what is here presented as promoting the education of the student cannot fail to enhance the social value of the future citizen.

Again, we do not seem to neglect, nowadays, to take into account the very important factor of connecting up the school-room work with the student's outside experiences wherever possible. May I then be indulged in dwelling a short while on what is called "pure science?" In fact, as I am trying to show it is just this aspect of physics which is so important for the purpose under discussion. In this connection, I should like to quote a passage from Colvin. Regarding the superior disciplinary value of pure science—he says: "Through the facts which it presents, ideas of procedure and of truth may be developed which function in a wider human experience, greatly to the uplift of the race; (2) the content and method of pure science is such that it has a broader field of application than has applied science, and can function as an identical or similar element in more situations than can applied science; (3) the emotions which the pure seeking after truth arouses is higher and less likely to be deadened by other emotions than are the ideals of economic improvement and social betterment

which are the aims of an applied science." The last of these statements, it seems to me, requires some qualification. The author has reference only to the primary *aims* of what are sometimes conveniently designated as "pure" and "applied" science. We recognize no essential difference, of course, between the two as science, and that this "economic improvement and social betterment" is in fact impossible without "pure" science as a fore runner is precisely one of the facts that, in my estimation, deserves a greater emphasis in the teaching of a science.

Thus, I would emphasize the history of famous researches. As has been suggested, this can be accomplished by library work, though you know how little time there is left at the student's disposal for this sort of reading. Couldn't more be done in the class-room, where it would be more intimately associated with the matter in hand? Probably not all original texts would be as interesting for this purpose as, for example, that of Galileo's "Two New Sciences," the verbatim readings of parts of which, in the class-room, I have found very effective.

It is not necessary to urge you to point out the historical significance of Galileo's experiments or, what is almost of more importance, the fact of his making experiments at all. Again, in the case of Newton, who is not impressed with the immense significance of that feature of his Second Law which is contained therein only by implication, namely the principle of the independence of forces? It brought order out of chaos. It is amusing to observe the old notions living over and over again in the minds of one's students who are at first so naïvely incredulous of the logical consequences of this principle.

Much can be made out of an inspection of the genesis of wireless telegraphy. The subject is full of interest to the student and affords a striking and typical illustration of the fact that should be impressed on his mind, viz., the fundamental importance of pure research as a basis for invention. You cannot invent something, the very principle of which you are not only ignorant of, but for which you would never come to the point of inquiring. A recent biographical essay puts it very vividly something like this: Can you imagine a surgeon, before the discovery of X-rays in 1895, asking for a type of radiation capable of penetrating the bones and tissues of the body with varying degrees of intensity, affecting a photographic plate and, in addition, having the property of causing various materials to fluoresce? Even if such an unthinkable request were made, how and where would one look

for such radiation? This discovery could have come only as a culmination of the labors of many minds through years of research on vacuum tube discharge.

It is to be hoped that not many high school graduates are of the opinion once expressed by a student of mine in a college class a few years ago that "inventors used their brains, while scientists found out things by accident." Nevertheless, I am convinced that a little propaganda in the interest of pure research is far from superfluous. The case of Roentgen's discovery is, of course, only one of a number of illustrations of Pasteur's saying: "Chance favors only the prepared mind." And yet there is much popular misconception on the subject. In this connection it is of interest to remember that to the physicist of today X-rays, and their shorter wave-length neighbors, the Gamma rays, constitute his most powerful tool for investigating the structure of the atom. We cannot predict what this knowledge may lead to, but we may feel quite safe in asserting that out of it will come developments of momentous import to mankind.

Naturally the appeal is here to the more altruistic emotions. Yet there is a constantly growing number of instances of the practical application following hard on the heels of research; e. g., the X-rays and the electronic amplifier, to mention only two of the more spectacular cases. The majority of visitors to a research laboratory are almost sure to ask: "What is the good of all this?" Franklin's famous reply to such a question needs more advertising. As one writer says: "Pursuit of knowledge does not follow a straight line—it frequently halts and indeed often has to hark back. Such erratic progress cannot make a very urgent appeal to the practical mind." Pasteur once said to his students: "Your business, your especial business, must be to have nothing in common with those narrow minds which despise everything in science which has not immediate application." And yet Pasteur saved France a sum which, according to Huxley, was equal to the total war indemnity of the war of 1870-1871. Imagine the value of the electrical industries, for example, also having their roots in the discoveries of the investigators in search of truth only. A recent writer remarks: "Electricity was not harnessed by financiers, but by the monumental intellectual labors of Oersted, Ampere and Faraday."

The case of wireless telegraphy, used as an illustration above, is a fascinating one. You know Hertz was led to his epoch-making experiments by the theoretical work of Maxwell. Again the

latter put into mathematical form the earlier conceptions of Faraday, whose emphasis on the importance of the medium was to prove so fruitful in the later developments. It is thus also a striking instance of the fact that so many of the big "discoveries" or inventions are the results of a gradual growth, sometimes through many hands and brains. This is not to detract from the debt we owe the inventor, the point to impress is that the world needs both. It is interesting to indicate, sometimes, the relative importance of research and invention in a given case. Thus, in the case of the first incandescent lamp, the discovery of the fact that a wire can be rendered luminous by means of a sufficiently large current of electricity can certainly not rank, with respect to the effort and ingenuity involved with the production for the finished and practical lamp, which was the task of the inventor. But some of the latest improvements, such as the employment of argon, would not have been possible except for the researches that had no practical end in view. You have doubtless noticed the remarkable advertisements (if such they can be called) of the General Electric Company, setting forth facts such as the above. These would serve admirably for an occasional class text.

Another topic of importance is the "popularization" of science. I have just alluded to the misconception of the role of the accidental in the great discoveries. An elucidation of this matter is a proper subject of instruction in physics. The problem of inculcating a better understanding of what science proposes to do and how it goes about it might well receive more attention. I have often been struck by the paradoxical fact that the "man in the street" at one and the same time expects too much and too little from the scientific worker. By that I mean that he fails to appreciate the really wonderful things that are being done, because they lack a certain spectacular element, and yet he will often exhibit a naïve faith in his expectation of marvelous performances to be accomplished without either much effort or delay.

In this connection the student might be told something more of the nature and value of physical theories. There are so many occasions in a course of elementary physics that give good opportunities for this purpose. Probably it will reverse the notion of many students to be told that one of the most important uses of a theory is to suggest experiment. The Hertz experiments are a case in point.

It is, of course, a question how and to what extent the matters I have just touched upon above can be successfully taught, par-

ticularly in the secondary schools, where they are, in one sense, of greater importance, since a wider contact with the public is established there. Prof. Snedden, after stating that "it is as hard today to find genuine justification for the teaching of physics according to the formulation and methods accepted in ninety per cent of our high schools as it is to find such justification for Latin for boys, algebra for girls or ancient history for both," remarks that "We do not know yet how to organize or administer a cultural course in science."

I have sometimes felt that perhaps we have gone too far in the direction of laboratory work, especially in the matter of quantitative experiments. I am speaking now, of course, only in regard to the cultural side of physics teaching. From my own experience, with reference to students above the average, I have come to feel that there is a danger in too close application to quantitative experimentation. The student is often too busy, in fact, "taking readings" to have any time or repose for envisaging the essential phenomenon as disclosed by the experiment itself. "He cannot see the woods for the trees." I doubt very much whether, in many cases, the taking of measurements and substituting to verify a given equation will produce as lasting an impression as an effectively arranged lecture table demonstration. The idea of the laboratory experiment is, of course, to give the student "first hand knowledge" and a more intimate contact with the phenomenon in question, but too close an approach, especially when all the attention is focussed on detailed readings only, may defeat the very object sought.

Naturally, then, I was quite favorably impressed with an editorial that appeared in Nature not many years ago. The writer was making a plea for a greater proportion of science teaching in the schools, and, while many of his references to conditions in England would not apply here, his remarks on the quality of the teaching are, I think, pertinent anywhere. He doubts the efficacy of modern method of teaching in respect to fostering interest in science as compared with that of former times. To quote: "Personal observation, intelligent inquiry, quantitative tests are, of course, essential factors of scientific method, but we believe that to insist upon all school science being controlled by them is a mistake." He considers it more important to awaken interest which will continue when school days are over and thinks that the descriptive and qualitative school science of a generation or two ago was better adapted to promote such continued

interest than the quantitative work in the narrow fields mapped out for instruction today. He also stresses the importance of the popularization of scientific knowledge, holding that a scientific novel by H. G. Wells is of great value in directing attention and arousing interest in things scientific. I have always believed the expounder to be as essential as the discoverer; after all, science is for people. It requires a rare ability of clear expression and even charm to hold the attention of the lay reader. Physicists will be reminded of Tyndall, Soddy and Lodge, to mention only a few of the outstanding ones who have done wonders along this line. As teachers we ought to strive to do our utmost in that direction, with the opportunities given us in the class-room.

The spirit of this article is quite in harmony with the ideas which Prof. T. Brailsford Robertson expressed about the same time. He deplores the high degree of specialization in the present day scientific training as tending to obscure that larger vision of the significance and influence of science on the material and spiritual welfare of mankind which, he says, alone confer meaning and dignity upon the task.

As I have said at the beginning of this discussion, it is a matter of proportioning the emphasis on the elements entering into the teaching of the subject. What is desired, it seems to me, might be expressed broadly as more pressure on the *educational* rather than on the *training* side of physics teaching. For the furtherance of the highest interests of society as a whole it is the education of the individual that counts.

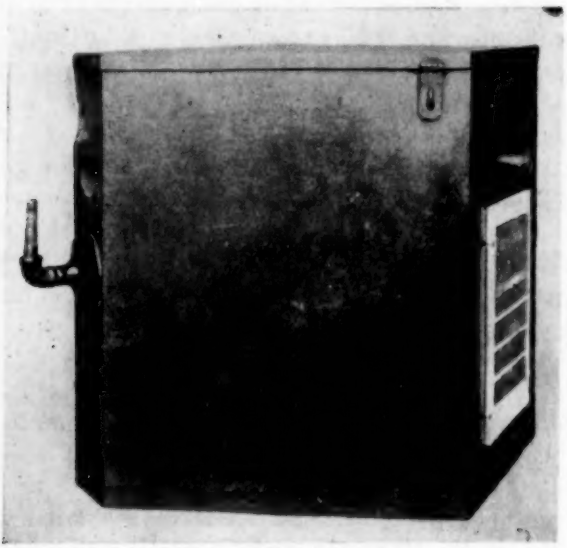
It is certainly not too much to say, in the case of the great majority of our students of physics, that their intelligent attitude toward the subject will mean vastly more to the promotion of the science itself and the best interests of society than their necessarily limited acquaintance with the particulars of the subject itself. Such an attitude is truly a vital part of that scientific attitude that we are all anxious to instil.

THE SPECTROSCOPE IN THE ELEMENTARY CHEMICAL LABORATORY.

By H. C. KREMERS,

University of Illinois, Urbana, Ill.

In many laboratories where general chemistry or qualitative analysis is being taught it is frequently the custom to have a spectroscope available for student use. The spectroscope not only teaches the student the type and relative position of the various lines of the flame spectra of some of the elements, but also serves as an aid in the identification of the alkali and alkaline earth metals. In order to have a spectroscope readily available to the students it is almost necessary that the instrument be either placed directly in the laboratory or in some convenient darkened corner. Proper supervision by the instructor also makes this condition necessary.



It has been the experience in this laboratory that in the hands of students the spectroscope was continually out of adjustment and being constantly exposed to laboratory gases very soon became so badly corroded as to render fine adjustment almost impossible. It was usually found necessary that the spectroscope be completely overhauled and readjusted at least every year.

SPECTROSCOPE MOUNTED IN BOXES.

In the fall of 1917, three medium grade spectroscopes of American make were purchased to be used by our students in qualita-

tive analysis. These spectroscopes being of a cheaper grade were rather difficult to adjust and keep in working order. In order to overcome the constant attention that these instruments required they were mounted in specially designed boxes. The accompanying photographs will bring out the idea quite clearly. These boxes were constructed of one-half inch lumber and painted a

flat black both inside and out. The modified Bunsen burner in position before the slit and the fish tail illuminator for the scale are permanently mounted on the outside of the box. The light from the burners can readily gain access to the spectroscope by means of small holes cut in the box. After proper adjustment of the prism, scale and slit the box is locked and all tampering by students prevented. The large slot cut in the front of the box provides ample movement for the eye piece. The eye piece can, also, be readily focused from the outside. To facilitate the use of the instrument a chart of the flame spectra of the common elements is mounted on the box directly underneath the eye piece.

These charts were calibrated to correspond with the calibration of the instrument.

Results Satisfactory.

The three spectroscopes referred to above and mounted as described have been in use continuously and at the present time are still in perfect working order. Some distinct advantages have been demonstrated.

1. The spectroscope is made readily portable and no darkened room required. It can readily be taken into the laboratory and kept under supervision and direction of the instructor.
2. Corrosion by laboratory fumes is reduced to a minimum.
3. Once the spectroscope is adjusted, tampering by inexperienced students is prevented.
4. With the instrument near at hand the students are more inclined to familiarize themselves with its use and advantages.

THE VALUE OF FREQUENT TESTING.

By Charles H. Sampson.

Huntington School, Boston, Mass.

Not so very long ago (the practice is still in vogue in some schools) pupils were ranked very largely on the work which they passed in for correction. This method of determining a grade for any and all abilities has changed for the better in most of our preparatory institutions. It is well that the change has taken place both for the school and for the student.

Work outside the class is often well and conscientiously done. On the other hand, there are always a few among us who seem to have been placed on earth to spoil the good intentions of the many and to grade a student because of what his home work indicates is very often an injustice in a class because a poor student and a good student receive an equal grade. Grading on the basis of grades received in frequent tests is by far the most satisfactory and most just to all concerned.

Tests should be given weekly in all subjects that are scheduled for every day. They should cover the work that has been covered during the preceding week. These examinations should be short but the questions should be selected with great care and they should aim to bring out of the mind of the student an understanding of some important principle. The making out of a test is not the matter of a few moments' time nor of the careless selection of problems or questions. A question should not be asked merely to obtain an answer but rather to determine the weaknesses that may exist in one's knowledge of any given subject. If the faults are known there can usually be a remedy.

It is not necessary that tests be given at any particular time but it is better if some fairly close system be followed. If possible, tests should be given at convenient stopping points, such as at the end of a chapter, etc.

It has been said that men are creatures of habit. This trait exhibits itself in the matter of testing as elsewhere. Boys and girls are no exception to this rule, even though they have not reached maturity. In fact, there is no better time in life to form good habits. Becoming accustomed to frequent testing is an excellent habit for all young people to form who expect to go to college. It will do no harm to those who do not expect to advance educationally.

There is another exceedingly important reason why preparatory school students should welcome the opportunity to be frequently tested. This reason is not fully realized during the progress through the course but when the college examinations are close enough at hand to make one begin to feel nervous and uncomfortable the good points of the reason will be evident. If frequent testing has been the rule, there will not be the usual apprehension and fear that grips one previous to attempting the ordeal which most of those who enter college are obliged to undergo. Nothing could be more ideal than for one to go up to the college entrance examinations as he would go to one of his frequent tests. It is true that one of the prime causes of failure in these examinations is that which we call "getting rattled." Frequently, brilliant students fail because of this confusion. Frequent testing will do much to eradicate this evil.

The time may come when entrance to college will be universally decided by other means than by written examination. The College Entrance Examination Board is still doing a big business, however, and will no doubt so continue to do for a long time to come. As long as this situation is as it is let us not under-rate the value to be derived from frequent testing.

Incidentally, it may be said that there are other values to be derived from frequent testing that are of great benefit to the individual himself, as he progresses through college. No boy or girl can successfully encounter a series of frequent tests without forming very valuable habits of industry and study. And who will say that such habits as these will not be of great value in any future undertaking be it in advanced school work or in the life work that one may choose to enter?

ARE ANY PRINCIPLES OF ORGANIZATION OF GENERAL SCIENCE EVIDENCED BY THE PRESENT TEXTBOOKS IN THE SUBJECT?[1]

By Ada L. Weckel,

Head, Biology Department, High School, Oak Park, Illinois.

General Science has existed for a number of years, and it has attained a legitimate place in the curricula of many of our best high schools. After long experimentation, an introductory course in the scientific study of common things is now generally recognized as an essential part of the educational opportunities of our secondary schools.

Since its introduction into the schools, enough time has elapsed to enable us to consider that the period of experimentation has passed. Out of these years of experimentation, some definite opinions have crystallized. These are indicated by the organization of the courses in the textbooks of General Science, and by the results which several investigators have obtained from questionnaires filled out by many of our best science teachers.

Many administrators, and some science teachers, too, are not aware of the uniformity which occurs in the content of the courses given in the text books of general science. This uniformity is due, I believe, to the fact that the authors are agreed on the dominant aims and purposes of the subject. An examination of the prefaces of our best textbooks shows that the aims of the writers are essentially the same as those of the science teachers who replied to a questionnaire sent out by Mr. C. M. Howe, of Hughes High School, Cincinnati, in 1918, and to another sent out two years ago by a Committee on Reorganization of General Science of which Mr. Fred Barber was chairman and of which I was a member.

In the judgment of the eighty teachers of science who replied to Mr. Howe's questionnaire, the three leading *aims* in the teaching of general science in the first year of the high school should be to give each pupil:

1. Understanding, appreciation, and control of his everyday *environment;*
2. Appreciation of the *applications* of science in industrial and social life;
3. A fund of valuable *information* about nature and sciences.[2]

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[1]Read before the General Science Section of the C. A. S. & M. T., Soldan High School, St. Louis, November 25, 1921.

[2]From C. M. Howe: *Can and Should General Science be Standardized? School Science and Mathematics*, March, 1919, pages 248-255.

The dominant *purposes*, then, of General Science as determined by these three leading aims are to give each pupil the greatest possible understanding, appreciation, and control of his everyday *environment;* to acquaint him with some of the most important industrial and social *applications* of science; and to furnish as wide a fund of *information* about nature and science as time permits.

In the questionnaire sent out by the Committee on Reorganization of General Science, teachers were asked first to rank in order of their importance the three following aims:

1. The problem-seeing and the problem-solving aim;
2. The knowledge aim;
3. The appreciation aim.

Second, they were asked to rank in order of their importance six additional aims which were similar to the ones which Mr. Howe had previously used.

From the results obtained in this investigation, it was found that teachers ranked the first set of aims in the following order:

1. Problem-seeing and problem-solving aim;
2. Knowledge aim;
3. Appreciation aim.

From the six additional aims, the three which were selected as being the most important were the same as the ones which Mr. Howe found were considered of first importance. The ranking also of these three aims was the same for both groups of teachers.

Prefaces in our textbooks in General Science indicate that the writers recognize the same aims and purposes as those given by the teachers replying to questionnaires. Mr. Trafton, for example, in *Science of Home and Community*, says: Applications of science more and more dominate our lives. Any sane system of education must see to it that boys and girls living in the midst of these applications, which form such an important part of their everyday life, are educated in terms of this environment, in order that they may better appreciate it and adapt themselves to it." The authors, Mr. Barber and others, of *First Course in General Science*, believe that the primary function of first year General Science is to give, as far as possible, a rational, orderly, scientific understanding of the pupil's environment to the end that he may, to some extent, correctly interpret that environment and be master of it. These and similar expressions which may be found in almost any one of the textbooks, indicate that the present day tendency is to give the child an understanding of those

scientific problems which are vitally connected with his every-day life.

Recognizing the unanimity which exists in the three basic aims: *environment*, *application*, and *information*, consideration may now be given to the selection and the organization of the materials presented in our general science courses. Writers of textbooks and teachers of science are also quite generally agreed upon the organization of the subject matter of general science. They believe that the subject matter should be organized around the *interests* and *experiences* of the pupils rather than around the principles and laws of any branch of science.

In the replies to the questionnaire sent out by the Committee on Reorganization previously referred to, eighty per cent of the teachers expressed their preference for a course organized about natural units: those having some common process, or activity, or set of concepts functionally related to life, rather than about units having scientifically related principles as a core. In most of the textbooks the materials have been selected from the pupil's environment and then organized from the human rather than from the scientific point of view.

The organization of any course in general science will depend upon the selection of the materials for the course, and this selection in turn depends upon the aims of the course. With the aims so clearly defined, it is inevitable that the content of the courses as given in the textbooks is very uniform. Many do not know how similar the courses are, and others, opponents of the subject, are not willing to recognize the fact.

In an effort to determine what underlying scientific principles and fundamental concepts occur most frequently, I have made a careful examination of the following fourteen textbooks:

1. Barber, First Course in General Science. Henry Holt Company.
2. Brownell, General Science. Macmillan Company.
3. Caldwell & Eikenberry, General Science. Ginn and Company.
4. Clark, An Introduction to Science. American Book Company.
5. Elhuff, General Science. D. C. Heath Company.
6. Hessler, The First Year of Science. Benjamin Sanborn Company.
7. Hodgdon, Elementary General Science. Hinds, Hayden & Eldredge Co.
8. Lake, General Science. Silver Burdett Company.
9. Pease, General Science. Merrill Company.
10. Snyder, First Year Science. Allyn and Bacon.
11. Smith and Jewett, Introduction to the Study of Science. Macmillan Company.
12. Trafton, Science of Home and Community. Macmillan Company.
13. Van Buskirk and Smith, The Science of Everyday Life. Houghton Mifflin Company.
14. Weekel and Thalman, A Year in Science. Row, Peterson & Co.

A tabulation of the results of my investigation follows:

FUNDAMENTAL CONCEPTS AND TOPICS WHICH OCCURRED IN:

I. All Fourteen Texts.

1. Atmospheric pressure
2. Principle of and kinds of thermometers
3. Definitions and applications of humidity, dew point, condensation, saturation

II. Thirteen of the Fourteen Texts.

1. Oxidation
2. Transference of heat: conduction, convection, radiation
3. Soils, origin and composition
4. Study of weather maps

III. Twelve of the Fourteen Texts.

1. Composition of atmosphere
2. Winds, cause of and general circulation
3. Molds and Bacteria: structure, development, relation to diseases and decay
4. Foods and nutrition

IV. Eleven of the Fourteen Texts.

1. Study of the cell
2. Calorie, value of
3. Structure and function of parts of human eye
4. Heat, nature and origin
5. Electricity, elementary presentation of
6. Sanitation and diseases: germs, toxins, antitoxins, disinfectants, sterilization, vaccines, etc.

V. Ten of the Fourteen Texts.

1. Seasons, cause of
2. Gravity, definition
3. Pumps
4. Storms, causes and common types
5. Sewage disposal
6. Types of electric cells
7. Lighting systems: kerosene, gas, electric, acetylene

VI. Nine of the Fourteen Texts.

1. Properties of matter
2. Elements and compounds
3. Plants: structure and function of root, stem, leaves, flowers
4. Molecular theory
5. Water power and its applications
6. Manufacture of artificial ice
7. Steam engine, principle of action and application
8. Sound, nature of
9. Light, nature of and properties
10. Carbon dioxide: source, role in nature, fire extinguisher
11. Cell division and reproduction in plants and animals
12. Machines: lever, screw, pulleys, wheel and axle, inclined plane
13. Solution, especially as applied to hard and soft water
14. Vaporization.

VII. Eight of the Fourteen Texts.

1. Drainage and irrigation
2. Erosion
3. Distillation
4. Solar System
5. Physical and chemical changes
6. Heating systems
7. Magnetism
8. Acids, bases, and neutralization
9. Injurious insects
10. Osmosis
11. Filtration

12. Expansion of solids, liquids, and gases
13. Electric bell, telephone, telegraph
14. Ventilation, principle of and different systems
15. Combustion

VIII. Seven of the Fourteen Texts.

1. Siphon
2. Human ear, parts and functions of each
3. Weathering
4. Fertilization
5. Lenses, kinds
6. Day and night, cause
7. Capillarity
8. Gasoline engines
9. Plant nutrition

IX. Six of the Fourteen Texts.

1. Metric system
2. Density and specific gravity
3. Archimedes' principle
4. Survey of animal kingdom
5. Time, standard, etc.
6. Electrolysis
7. Fuels and carbon compounds

X. Five of the Fourteen Texts.

1. Human body, structure of
2. Energy: kinds, measures for
3. Life processes in animals
4. Pasteurization
5. Properties of protoplasm
6. Mechanics of respiration
7. Pollination and fertilization in plants

XI. Four of the Fourteen Texts.

1. Seed dispersal
2. Glaciers
3. Latitude and longitude
4. Cohesion and adhesion
5. Wind power
6. Human voice
7. Earthquakes and volcanoes
8. Parasites and saprophytes
9. River development
10. Economic botany

XII. Three of the Fourteen Texts.

1. Analysis and synthesis
2. Boyle's law
3. Hydraulic press

Total number of topics listed above, eighty-nine.

Except for the phraseology and the time involved, no difficulty arises in a mere listing of the concepts given in textbooks. When one attempts, however, to analyze this subject matter, to place it in as few large units as possible, and to recognize the larger units most frequently used, the task becomes most difficult.

After the selection of the materials from the child's environment has been made, writers frequently group it about one of two centers: either the *home* or the *community*; occasionally both are used. It is then further divided into such topics as

atmosphere, water, methods of transportation, building materials, household chemistry, foods and nutrition, the universe, oxidation and its relation to life, and a multitude of others, all usually well chosen.

About the larger units or topics which I found occurring most frequently in the textbooks, I have attempted to formulate what might be termed a composite course by placing under these topics the fundamental concepts and scientific principles which I found occurring in the frequency which I have already given.

If I have succeeded in doing this without personal bias and with any degree of skill, I shall then have a standardized course based upon the courses as given in the textbooks which I have examined. Since a large number of representative books has been examined, I think that I am justified in presenting the following outline as a standardized course in General Science based upon the courses developed by the textbook writers, most of whom are or have been high school teachers.

OUTLINE OF STANDARDIZED COURSE BASED ON TEXTBOOKS.

I.

Atmosphere.

1. Physical properties and mechanics of gases
2. Chemical composition
   - elements, compounds, mixtures
   - molecular theory of matter
   - study of oxygen, nitrogen, carbon dioxide
   - oxidation
3. Atmospheric moisture
   - evaporation
   - humidity
4. Weather
   - air pressure
   - pumps
   - barometer
   - temperature
   - winds
   - storms
5. Respiration in plants and animals
   - hygiene of breathing
   - ventilation

   } Frequently included under IV.

II.

Water.

1. Physical properties
2. Chemical composition
   - solution
   - hard and soft water
3. Mechanics of liquids
4. Distillation
5. Evaporation
   - refrigeration
   - manufacture of artificial ice
6. Water supply
   - source

purification
7. Sewage disposal
8. House piping
9. Hot water heating, often included under VI.

III.

Earth.

1. Its relation to the universe
   stars and solar system
   earth and its seasons
2. Soil
   origin
   physical structure
   erosion and sedimentation
   fertility
   soil water
   drainage
   irrigation

IV.

Life on Earth.

1. Plants
   cell, structure and activities
   parts of plants and their functions
   food production
   food storage
   reproduction
2. Animals
   groups
   human physiology (often omitted)
   reproduction
   insects and diseases
3. Bacteria, yeasts, and molds
   human diseases
4. Hygiene and sanitation

V.

Foods and Nutrition.

1. Foods
   need of
   production
   measurement of food—calorie
   composition
2. Digestion
   organs of
   hygiene
3. Diet
4. Adulteration.

VI.

Machines, Work, and Energy.

1. Work of running water—water wheel, turbine, etc.
2. Work of simple machines
3. Measurements and kinds of energy
4. Heat
   transmission of
   fireless cookers
   methods of heating our homes
   coal
   work done by heat—steam engine
5. Light
   nature
   color
   human eye
   methods of lighting our homes
6. Sound
   nature

human ear
7. Electricity and magnetism
measurement
electric generators
applications of electricity
electric bell
automobile
telephone
telegraph

In presenting this outline, my paper is concluded so far as the problem assigned me by your chairman is concerned. I can not refrain, however, from expressing a few convictions which have come out of the study made for the preparation of this paper and out of many years of observation and participation in the General Science movement:

1. Many of the courses in General Science include more material than can be given to first year high school pupils in one year.

2. Relatively too much emphasis is being placed upon the physical environment of the child. More civic biology should be included in many of the courses.

3. The project method is not feasible for the overworked teacher, for the one who has very large classes, nor for the beginner.

4. The years of experimentation in General Science need not be looked upon with the disapproval and contempt so frequently evident, for often even inexperienced teachers give better courses when all initiative and interest have not been destroyed by overstandardization of the subject taught.

5. There is a surprising unanimity in the aims and purposes of General Science and also in the subject matter included in the courses now given.

BIOLOGY AND PROJECT WORK.

By WINIFRED PERRY,

Francis W. Parker School, of San Diego, California.

To visit a class in High School Biology, in which there is no adopted text-book, no formal recitation, and in which each student is working on an individual problem of especial interest to himself, may at first seem revolutionary, if not evolutionary. Yet the observer must be impressed by the spirit of activity and cannot but be interested in the variety of investigations going on in the laboratory.

There are many advantages to be gained from this form of project work, which I am conducting in the Francis W. Parker

School of San Diego, under the direction of Professor J. L. Meriam of the University of Missouri, who is this year acting as professional adviser in this school. Mr. R. K. Watkins, associated with Dr. Meriam at the University of Missouri, is conducting similar work with the emphasis upon General Science.

Upon seeing the plan in operation the observer must agree that it is very much like life outside of school. Each boy and girl has his or her own work to do, yet they are not too busy to aid their neighbors with information or advice, or too absorbed in their own work to be interested in the "Field nest" for the study of ants, or an especially good test for protein which a neighbor has to show them.

A small, though fairly well-equipped laboratory is used for this class. In the center of the room are long tables. Around two sides of the room, directly under the windows, are additional tables on which apparatus, materials, etc., which are constantly used, are placed. In one end of the room are book-shelves, filled with the latest books, magazines and government reports.

Two consecutive periods of forty minutes each are daily devoted to biology. Usually the last fifteen minutes are used for a seminar or conference when the results of the various projects are given. On some days no reports are given. Again an entire period is devoted to the discussion, depending upon current conditions. No home study is required in this course, although many books are voluntarily taken out for home reading.

A long list of possible projects is constantly before the students on the bulletin board, from which they may choose their projects for study. In this method of allowing boys and girls to choose for themselves their study, there may be a possible danger that their work may be one-sided and not the well-rounded course which a general course in high school biology should be, by tradition. However, I think that the possibility is not very serious, for the teacher, who becomes a counsellor and to a certain extent fellow-student as well, can easily suggest a new field of activity if she feels that a certain student is giving too much attention to one subject. Should this condition exist, is it of great importance? All of us have our hobbies and we should be intensely interested in one or a few things, rather than manifest a luke-warm interest in all things.

It is trite to say that what we teach is governed by the students' experience and present interest. These two factors have determined to a great extent the nature of the two hundred or

more projects which I have offered to my students. The following ten projects were being investigated at one particular time:

1. To diagram the life history of a fern.
2. To demonstrate plant tropisms.
3. To collect and identify ten autumn weeds.
4. To find out what hormones are and their effects upon the human body.
5. To make a chart showing food values in various common foods.
6. To observe the social nature of ants in a "Field Nest."
7. To learn the chief contribution of ten biologists.
8. To learn the characteristics of some of the more desirable breeds of our domestic animals.
9. To investigate the grasshopper in its relation to crops.
10. To learn how fleshy fungi are reproduced.

At this time no credit value has been assigned to the various investigations. Students are asked to record the time used for a given project and eventually a scheme of values based on the time and effort expended can be worked out if it is deemed advisable. However, these boys and girls are not thinking in terms of credits and grades, but rather are they concerned with their progress and the information they are gaining for themselves and their associates.

That this plan of work saves a vast amount of time can be easily understood. No pupil wastes time listening to a classmate recite a thing he, too, knows well. It is perfectly natural for the discoverer and investigator to desire to tell his fellows of his accomplishments. Thus, the conference or seminar time when all gather about one long table to learn from each other is eagerly looked forward to by all of the students. Often these reports are ruthlessly criticised, sometimes they are questioned and frequently the remark is made, "This is related to my project."

In some instances it is possible for a student to have several projects under way at one time, especially if they are of an experimental nature or take the form of collections. Thus a student may have several interests instead of thinking of but one phase of biology at a time, as he usually does when the text-book and the usual recitation method are employed.

As in the business world, one authority does not usually decide an issue, so these boys and girls are taught to refer to several books before drawing their conclusions. Some spirited arguments occur when Mary finds that the information obtained from one authority is at variance with that quoted by Charles.

Obviously this type of work demands a great array of books and magazines. Those in charge of the school have been very generous in supplying a goodly number of the newer books in the field of biology, as well as the current magazines. These books

are easily supplemented by others from the public library. Some of the books and magazines which are most used are:

Arnold—Sea Beach at Ebb Tide.
Arnold and Gilbert—Text-book of Botany.
Bailey and Gilbert—Plant Breeding.
Coleman—The People's Health.
Conn and Buddington—Advanced Physiology and Hygiene.
Coulter—Plant Life and Plant Uses.
Davison—Practical Zoology.
Duggar—Plant Physiology.
Fisher and Fiske—How to Live.
Gruenberg—Elementary Biology.
Harwood—Creations in Plant Life.
Hunter—A Civic Biology.
Hunter—Laboratory Problems in Civic Biology.
Hunter and Whitman—Civic Science in the Home.
Hutchinson—Handbook of Health.
Hutchinson—Preventable Diseases.
Kellogg and Doane—Economic Zoology and Entomology.
Leavitt—Outlines of Botany.
Price—Handbook of Sanitation.
Sargent—Plants and Their Uses.
Reveley and Bailey—Biology for High Schools.
Snyder—Chemistry of Plant and Animal Life.
Transeau—Science of Plant Life.
Waters—Essentials of Agriculture.
Year Books of the U. S. Department of Agriculture.
The American Botanist.
The Guide to Nature.
Good Health.
The Literary Digest.
The Nature Study Review.
Public Health Reports.
The Scientific Monthly.
The Scientific American.

Because the student has chosen a project of personal interest to himself at that particular time, the incentive to study comes from within himself. The problem of teaching boys and girls how to study is largely taken care of by this form of project work. Each one has a definite thing to do. He has the materials, books and apparatus at hand to do it with. He has previously planned how to do it. His problem is to find out as much as he can about this project, and his results are usually pleasing to himself and his teacher as well. The time really becomes a period of supervised study when the teacher in charge may move about among her pupils, giving suggestions as they are needed. The changed attitude on the part of some students whom I knew last year is very marked. The transition from the idea of doing the minimum to that of the maximum is quite evident. At the close of the first two weeks I made the statement that more work had been accomplished by the class than by previous classes in four weeks' time. This condition persists and I am sure will up to the close of the year.

This type of teaching undoubtedly makes greater demands on the teacher's energies, in some respects, than the usual recitation method. Yet, it has greater compensations. Chief among these is the very evident progress and steady development of her pupils in habits of initiative and responsibility. To note the increasing ability of boys and girls to use books easily and intelligently as sources of information and to think a problem through to a logical conclusion is indeed a reward.

The added effort expended in supervising as many projects as there are pupils in a class is largely offset by the following conditions: The problem of discipline has disappeared because everyone is busy. Then when pupils have been absent there is not the usual problem of making up the work with them. They merely resume their work at the point at which they left it and a most irksome procedure is spared both teacher and pupil. Then in the usual laboratory, due to a lack of equipment and space, much of the work necessarily takes the form of demonstrations, too often performed by the teacher. Using this method of procedure each student may have the opportunity throughout the year to perform for himself the various experiments and thereby acquire a technique which is invaluable.

In the working out of these projects a minimum of written work is employed with a maximum of drawings, chart-making, collections, etc. When a student has completed a project he makes a report on a 5 x 8 card, which is filed under his name for future reference. A typical report follows:

Lowe, Katharine
October 31, 1921

1. To find out how mushrooms are reproduced.
2. I chose this project because there had been rains and mushrooms and I wanted to know the difference between toadstools and mushrooms.
3. Materials
   a. Mushrooms and toadstools.
   b. Readings.
      1. National Geographic, May, 1920
      2. Plant Life and Plant Uses—Coulter
      3. Bulletin No. 175, Bureau of Plant Industry
4. I read about fleshy fungi and how they are reproduced and then drew pictures and named the parts.
5. I found that the spores fall from the gills, and the hyphae grow forming mycelium, from which many sporophores grow.

That this project work in biology is working out well as far as the entire school is concerned is very apparent. An interest in the sciences throughout the entire lower as well as upper school has been developed. A boy's or girl's friends are naturally interested in what he or she is doing, and so this form of project work in biology may justly be termed a form of extension work.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge

University of Oklahoma, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to Homer L. Dodge, Department of Physics, University of Oklahoma, Norman, Okla.

VACUUM TUBES AND THEIR CHARACTERISTICS.

By Dr. William Schriever,

University of Oklahoma, Norman, Okla.

In a previous number[1] of this journal appeared the first of a series of articles dealing with the application of the principles of physics to wireless telegraphy and telephony. This paper discussed the action of each of the elements of a simple oscillating circuit and a method for producing damped electrical oscillations. In this, the second paper, the characteristics of vacuum tubes will be considered in detail.

Very hot substances, such as the filament of an ordinary incandescent lamp, give off electrically charged particles. These particles are called electrons; they are negatively charged. In fact an electron is an atom of electricity, or a little indivisible chunk of negative electricity. Its mass is only 1/1845 of that of a hydrogen atom. It is so very small that, if it were enlarged 1.2×10^{12} diameters, it would be only as large as a pea. A small sewing needle enlarged the same number of times would be about 430,000 miles in diameter, or nearly two times too large to slip between the earth and the moon. Swarms of these tiny negative charges are given off by the tungsten filament of an ordinary electric light.

Figure 7 shows an incandescent lamp in which has been placed an electrode b. If the terminal of b is connected through a suitable ammeter A to the positive terminal of a battery E, and the negative terminal of the battery is connected to the filament a, the ammeter will show that a current is flowing from b to a in the bulb. It will also be found that, when the battery E is reversed, no current will flow. This is just what is to be expected because, when b is positive, the electrons

[1] "The Production of Damped Radio-Waves" by William Schriever, Vol. 20, p. 681, November, 1920. The reader should also consult the following papers by Dr. Homer L. Dodge: "The Thermionic Valve", Vol. 19, p. 20, January, 1919; "A Thermionic Rectifier for Large Currents", Vol. 19, p. 273, March, 1919; and "The Thermionic Amplifier", Vol. 19, p. 439, May, 1919.

given off by a are attracted to it; when b is negative, these electrons are repelled and so no electric charge is transferred from a to b nor from b to a. Since an electric current consists of charges in motion, the stream of electrons from a to b constitutes a current. From the way the battery was connected when the electron current flowed, it will be observed that the direction of the current, as ordinarily defined, is opposite to the direction of flow of the electrons. Such a tube is known as a two-element vacuum tube, a Fleming valve, a kenotron, or a thermionic valve.

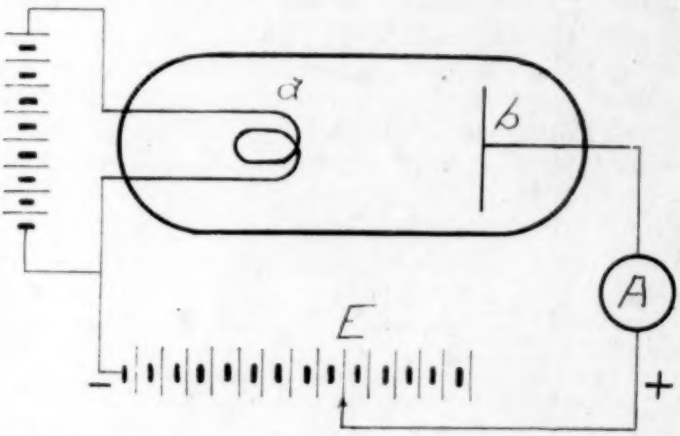


FIGURE 7.—A kenotron or Fleming valve: a is the filament, b is the plate.

The chief feature of the two-element vacuum tube is, that it allows current to flow in only one direction, namely, from the plate b to the filament a inside the tube. In other words, the tube is a rectifier. Therefore when an alternating difference of potential is applied between the plate b and the filament a, current will flow only during those parts of the cycles when the plate is positive with respect to the filament. The first curve of Figure 8 shows how the alternating potential difference varies with the time and the lower curve the resulting current through the tube.

In Figure 9 is shown the effect on the plate current of, (1), varying the plate potential, and, (2), varying the filament current. A constant current through the filament maintains it at a constant temperature so the filament emits electrons at a constant rate which is independent of the plate current. If, under these conditions, a small positive potential is applied to

the plate, a small plate current will be indicated by the ammeter *A;* twice this plate-potential will cause twice the current, and so on. Or it may be said that the plate-current varies directly as the plate-potential. This state of affairs is represented

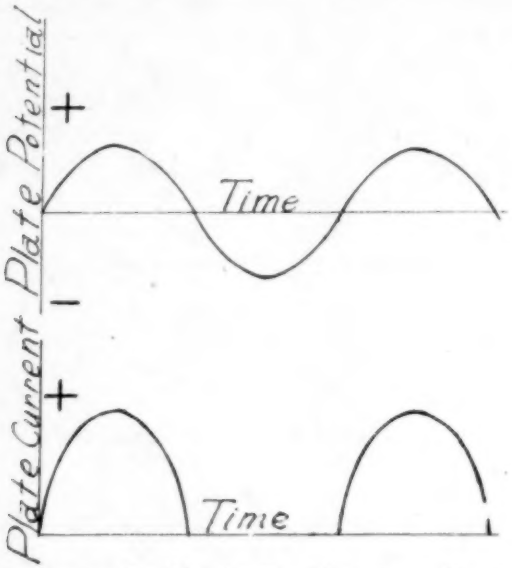


FIGURE 8.—Rectification by a kenotron; the plate-current flows only while the plate is positive.

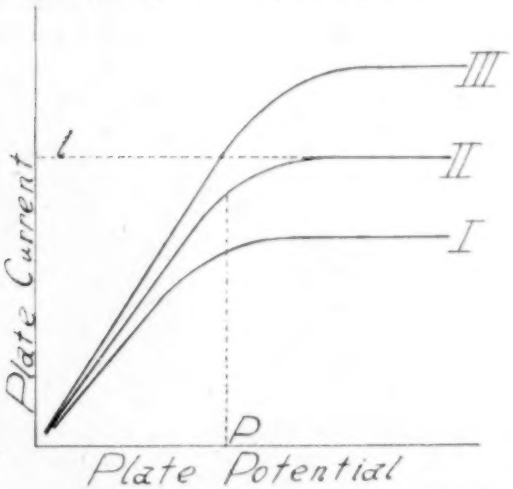


FIGURE 9.—Characteristic curves of a kenotron, for three values of the filament-current.

by the sloping straight part of curve II, Fig. 9, as far as the point corresponding to a value *P* of the plate-potential. At

this plate-potential the electrons are gathered up by the positive plates as fast as they are liberated; any further increase in the potential can therefore cause no further increase in the plate-current for the given constant current through the filament. This accounts for the horizontal portion of curve II. A larger filament current will increase the temperature of the filament; this will cause a greater emission of electrons and therefore a greater possible plate-current. A decrease in the filament-current has exactly the opposite effect. Curves I, II, and III are plate-potential plate-current curves for three values of the filament-current, curve III for the largest filament current and curve I for the smallest. The maximum plate-current obtainable for a given filament-current, is known as the "saturation-current" for that particular temperature of the filament. A current of strength i, Fig. 9, is the saturation-current for the particular filament-current employed when curve II was obtained.

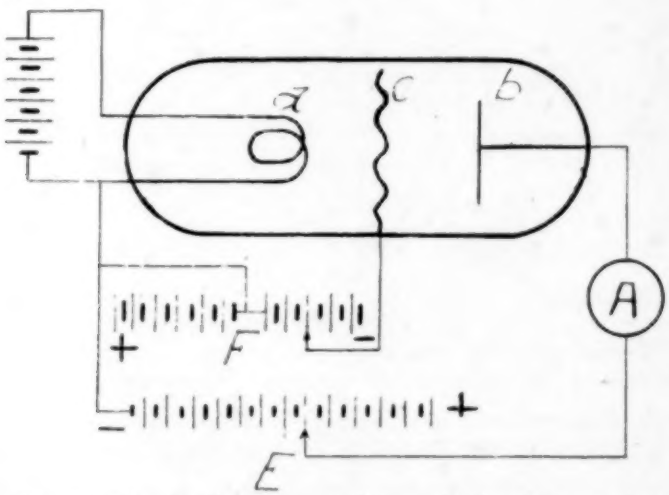


FIGURE 10.—A pliotron or audion: a is the filament, b is the plate, c is the grid.

In a later paper it will be shown how a two-element vacuum tube can be used as a detector of radio signals.

Figure 10 shows a three-element vacuum tube. The third electrode c consists of a wire screen; it is called the "grid." The grid is placed between the filament and the plate, usually, in practice, nearer the filament. The battery F is so connected that either positive, zero, or negative potentials, with respect to the filament, may be applied to the grid. If the filament-current and plate-potential are fixed and the grid is at zero potential,

the plate current will be the same as in a two-element vacuum tube. Now let the grid become positive with respect to the filament. The electrons will be attracted by the grid and this attraction will be in addition to that given by the plate; consequently they will be given a greater velocity. This increased velocity causes more electrons to reach the plate in a given time, and this is the same as saying that the electron current is increased. If the grid had been made negative with respect to the filament, the electrons would have been repelled by the grid but attracted by the plate and the resulting attraction would have been the difference between the two. Thus the effect of a negative grid is to decrease the speed of the electrons or, in other words, to decrease the plate-current.

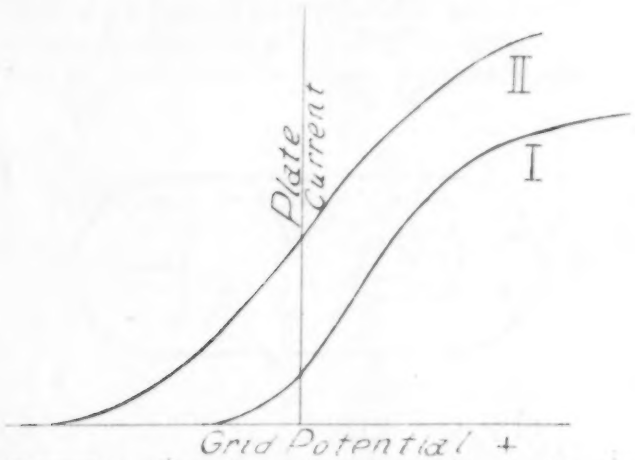


FIGURE 11.—The effect of grid-potential on the plate-current in a pliotron, for two values of the plate-potential.

Each of the curves of Figure 11 were made by reading the plate-currents when various potentials were applied to the grid; the plate-potential was kept constant for any one curve but was varied from curve to curve; the filament-current was the same for all curves. At the points where the curves cut the plate-current axis the plate-currents were the same as would have been obtained if the grid were removed, because it was at zero potential. The plate-potential for curve II was greater than that for curve I. It should be observed that a greater negative potential had to be applied, for curve II, in order to reduce the plate-current to zero, than was necessary for curve I. For a type VT-2 Western Electric Company tube, 55 volts negative potential on the grid were required to reduce

the plate-current to zero when the plate-potential was 300 volts and the filament current 1.35 amperes. The plate-current was 62 milliamperes when the grid was at zero potential.

For the particular tube just mentioned it will be noticed that one volt applied to the grid makes as much change in the plate-current as 300/55 or 5.45 volts change in the plate-potential would make. Along the straight part of the curve this ratio is about one to six. This tube is said to have an amplification constant of six and, from what has just been said, it will be seen that this means that a change of one volt grid-potential has as much effect on the plate-current as a change of six volts in the plate-potential.

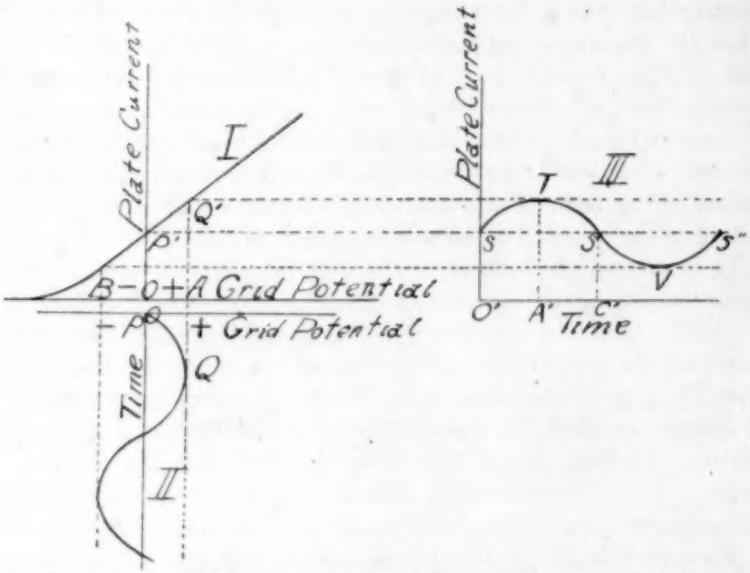


FIGURE 12.—Under proper conditions, an alternating potential applied to the grid of a pliotron will cause a pulsating unidirectional plate-current. The frequency and wave-form of the pulses will be the same as those of the impressed grid-potential.

The effect on the plate-current of an alternating potential applied to the grid is of greatest interest since it is this effect which is made use of in oscillator, modulator, detector and amplifier circuits. Future papers will contain information concerning each of these special applications; at the present time only a general description, which is applicable in all cases, will be given.

In Fig. 12, curve I is a grid potential plate-current curve (one of the curves of Fig. 11); curve II is a time-potential curve,

an alternating potential is represented. The units on the potential axis correspond to those of the grid-potential axis of curve I. Curve III is a time plate-current curve. The units along the current axis correspond to the units of the plate-current axis of curve I. The time units along the two axes of the figure are identical. At P the grid-potential is zero and the corresponding plate-current is that represented by the ordinate OP^1 or O^1S. One unit of time later the grid potential is $+Q$; the corresponding plate-current is therefore AQ^1 or A^1T. Another unit of time later, the grid is again at zero potential and the corresponding plate-current is CS^1. By similar constructions the points V and S,[11] and any number of intermediate points, can be obtained, thus giving the complete curve STS^1VS^{11}. Therefore, when the grid-potential plate-current curve for the tube and the time grid-potential curve of the impressed grid-potential are known, the time plate-current curve can be drawn. It should be observed that the resulting plate-current is not an alternating current, but is a pulsating unidirectional current. It may be looked upon as a direct current of strength OS upon which has been impressed the alternating current STS^1VS.[11]

The current which flows in the grid-circuit of a tube is very small compared to the change in the plate-current which is produced, and the necessary grid-potential is small as compared to the changes in plate-potential which would cause the same changes in plate-current. Therefore, a very small amount of energy is used in the grid-circuit to control a relatively large amount of energy in the plate-circuit. It is this characteristic which makes three-element vacuum tubes, sometimes called pliotrons or audions, so useful as detectors and amplifiers.

Thus far the action of Fleming valves and audions has been discussed in an elementary way. Little or nothing has been said about the construction of a tube or about currents and potentials used in commercial tubes.

Filaments for tubes are made usually of one of two metals, tungsten, like the filaments of the modern incandescent light, or platinum coated with oxides of rare earth metals. The oxide-coated platinum filaments seem to give the best results because the tubes are not as sensitive to slight changes in operating conditions. Most of the tubes on the market do not use the coated filaments. The VT-1 and VT-2 three-element tubes, used by the Signal Corps (made by the Western Electric Company) during the late war, had coated filaments. The plates

were two in number, one on either side of the plane of the filament. The grids were between the filament and the plates and each consisted of two vertical support wires to which were welded the cross-wires; each grid was like a wire ladder. Of course the two plates were connected inside the tube and the grids were similarly connected. The VT-1 was used as an amplifier tube and as a detector tube; the plate potential was about 40 volts and the plate current about 2 milliamperes. The amplification constant was about 8. The VT-2 tube used a plate-potential of 300 volts and a plate-current of about 40 milliamperes; it had an amplification constant of about 6 and served as a power tube. The VT-18 power-tube allowed the use of a plate-current of 100 milliamperes and a plate-potential of about 700 volts. It had a tungsten filament. In order to make it possible to build tubes of a given type, all with the same operating characteristics, it is necessary that the vacuum in them be very good indeed and great precaution must be taken in order to get out most of the gases which have been absorbed by the metal parts and the glass bulbs. If tubes are overheated while in operation, gases are liberated and the tube changes its characteristics entirely; very little gas will make it useless.

The next paper in this series will deal with the production of undamped radio-waves.

A DIAGRAM OF THE INTER-RELATION BETWEEN THE ORGANIC AND INORGANIC WORLDS.

By Gerard Krythe,

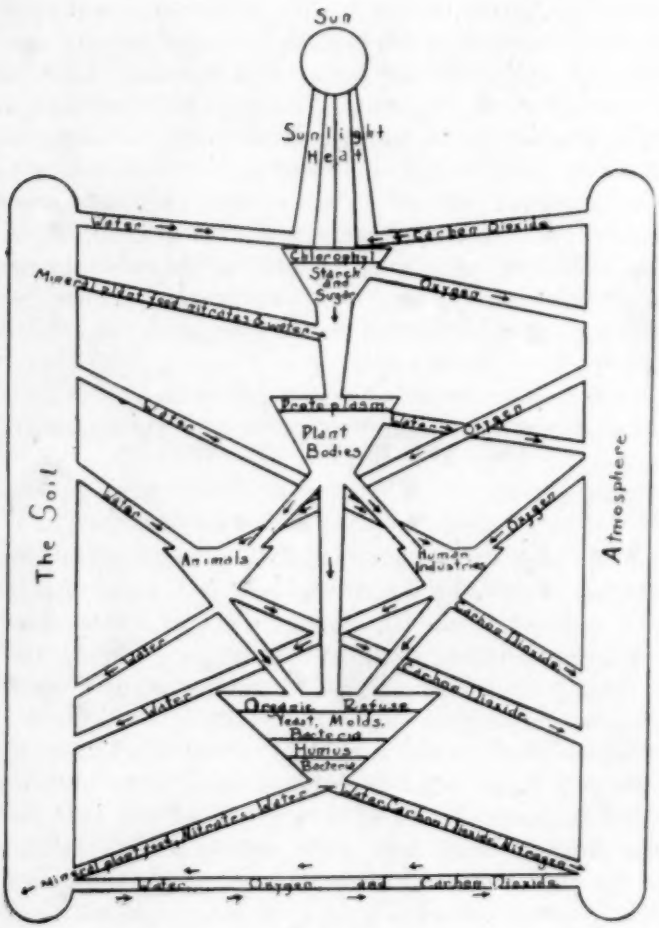
High School, Fort Morgan, Colo.

In our attempts to make our teaching as vital and effective as possible, we must often search the very recesses of library and brain for added and more illuminating material. When planning some diagrams to help in explaining the interrelation between green plants, fungi and animals, I finally hit upon one that proved to be very interesting and helpful.

During the study of the various life processes of green plants, animals, and fungous-like plants, we have many occasions to point out the interrelation of the various groups, and also the relations between them and the inorganic world. In order to review these relations and to combine them into one lesson, the use of a clear and interesting diagram is very valuable. Every biology student should get a vision of these beautiful relations, that are so simple and so necessary. It gives a feeling of con-

fidence and faith in nature's plan, that the world will move on, that "All's well with the world."

I made a large chart for class room use and explained the whole plan in the form of a review. After the explanation and discussion, the class was asked to copy the diagram and write up their own explanations. The results were very gratifying. Many remarked that although, at first, it seemed rather confusing, after they had drawn and studied the details, it became quite clear.



THE PROJECT METHOD IN TEACHING CHEMISTRY.[1]

By Ellinor Garber,

Shortridge High School, Indianapolis, Ind.

There has been so much discussion of the project method during the last few years that it is hardly necessary for me to start with the formal definition of a project. In science teaching this method has been more extensively used in connection with general science teaching than it has with the separate sciences of physics and chemistry, but there is no reason to allow this method to become the exclusive property of general science. Several years ago, a study was made of the projects chosen by general science pupils in the Horace Mann and Speyer schools in New York, and a list was obtained containing all the projects chosen by more than one pupil in the course of three or four years. Five of the most commonly used text books in general science were then examined to see what material these books contained, by comparing the indices of the five books. If a word appeared in the index of three out of five books and did not appear on the pupils' project list, that word was added. The combined list of pupils' choices and subjects suggested by the text books consisted of about two hundred words, each representing a general science project. An examination of this list showed that two-thirds of the projects indicated belonged to physical science, the remaining one-third to biological science. Our material then is not incompatible with project teaching. In chemistry our plan has been to make lists of projects embodying the material which we have always included in the more formaliy organized course. It was rather a surprise to me to find how readily this could be done, and how fully the material that we have regarded as essential could be presented in a project list. For example the subject of neutralization is covered by the following projects.

1. How are acids made? How is sulphuric acid made? How is sulphuric acid used in making other acids?

2. How is slaked lime made? How is it used in making ammonium hydroxide? In making sodium hudroxide? How can hydroxides be made starting with a metallic element?

3. How may acids be counteracted? How would you remove an acid spot from clothing? What would you give a person who had swallowed an acid? What would you do for a child who had eaten lye?

4. How can we determine the per cent of acetic acid in vinegar? Of citric acid in lemon juice?

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[1]Read before the Chemistry section of the Central Association at Soldan High School, St. Louis, Nov. 25, 1921.

After the project has been chosen, the pupil makes a complete investigation. The laboratory time is used in performing experiments, or in studying the reference books. Wherever it is possible, the work is completed by a study of the industrial application. In Indianapolis, the Fairmont Glass Works gives our pupils an opportunity to see a glass furnace in operation, to observe the method of molding bottles, and to see the annealing process. The Rauh Fertilizer Co. makes sulphuric acid by the Chamber process, and uses the acid in making phosphate fertilizer. The Indiana Refrigerating Co. has to soften all the water used in the boilers, and our pupils go there to find out what substances are actually used and in what quantities. Laundries have many different methods of water softening, which may be investigated by the students. After the pupil has completed his work, he makes a report to the rest of the class. In doing this he takes complete charge of the recitation, presents his project, performs the necessary experiments, and answers the questions of the class. He also asks them questions to be answered in their notes.

I should say here that our experiments in project teaching have always been in the second semester, after the atomic theory and the use of formulae and equations have been taught in the more formal way. The organization throughout the whole course is from the point of view of the pupil and his environment rather than from the point of view of the systematic presentation of subject matter. It seems to me that it is desirable for the students to have obtained some acquaintance with the laboratory and the subject before they are put entirely on their own responsibility in the project method. We may find that the project organization can be used earlier in the course than we are now using it. Certainly the work on nitrogen and carbon dioxide in the first semester might be handled in this way.

There are two aspects of the project method which make its application to the teaching of chemistry very advantageous. It gives us an effective way of connecting our subject with everyday life, and it gives us a chance to develop initiative and independence on the part of our pupils. We chemistry teachers all realize how important the subject is in everyday life. The woman in the home needs to know something of the chemistry of foods. A recent examination of the children in one of the most prosperous residence districts of the city, showed that 30 per cent

of the children were as much as 7 per cent undernourished. It would seem then that the mothers need to be taught the value of foods in terms of protein, fat and carbohydrate, and that they should know the difference between a calorie and a vitamine.

The citizen in a modern city needs to know chemistry to be intelligent on questions concerning sewage disposal, water purification, and gas manufacture. One of our problems has always been to teach our chemistry so that it was not a mere matter of symbols and formulae, test tubes and bunsen burners, but so that it would be a subject vitally connected with every-day life. I think the project method gives us a way of doing this. The pupil usually chooses a project in which he is interested, because he recognizes in it something which he has already met in his daily life. Pupils' choices show that their interests lie along these lines. Forty-three students were given a list including such subjects as the following:

Glass.
Mortar and plaster.
Hard water.
Manufacture of sulphuric acid.
Photography.
Nitric acid and explosives.
Carbohydrates.
Soap.

They were asked to indicate first and second choices. Soap was the first or second choice of twenty, and glass was named first or second by twenty-one pupils. Carbohydrates only received two votes. If I use this list again, I shall call them by their familiar names, and I think that more than two out of forty-three will be interested in sugars and starches.

The other aspect that I wish to emphasize is the project method as a developer of initiative. We hear from college men that the high school pupil does not know how to study. The industrial world says that the college does not train research experts who can attack a problem and master it. The general public says that our educational system does not produce individuals who can respond to a situation, and work out the problems suggested by it independently. It is interesting to note that the Dean of the Engineering School of Purdue University is putting his engineering freshmen to work on a series of problems or projects with very little suggestion as to the method of solution. In striving for efficiency and economy of time in education, we have led the pupil too much, the work has been too thoroughly planned and organized for him. We have not permitted him to form his own plans, and to learn by making his own mistakes.

When you tell a class to do experiment so and so in a fool proof laboratory manual the pupils do not have much opportunity to develop initiative and independence.

In using this method, we want to keep these two essentials in mind, the choice of the pupil so that he feels that it is his problem, his job, and brings to it the interest which is so large a factor in the accomplishment of any task. We want him to solve his problem in his own way, to develop his own methods of attack. Here we are met with some practical difficulties. If the choice is unlimited how may we be sure that important subjects are not left out, and that the individual projects may not be so unrelated that one member may get little or nothing out of another member's report. Time is precious; if we leave a pupil entirely to his own initiative, he may spend several days in the laboratory and really accomplish very little.

I have tried two methods of assigning projects. A list of projects can be made which are all related, as a list dealing with sodium and its compounds. This list should not consist of mere titles such as baking soda, but should suggest some of the questions involved in the project, as: How is baking soda made? What are the uses of baking soda? Why is it used for these purposes? The disadvantage of a list of this kind is that the pupil's choice is so limited that he may not be really interested in any project on the list. The advantages are several. It limits the material that must be available for the pupils' use. In a large class working on a wide range of projects it is often quite difficult to have apparatus and supplies readily available. The reports can be arranged in logical order, and in that way each individual report becomes of more value to the class. Each pupil may be asked to keep a small specimen bottle of his product, labelled with the chemical name, common names and formula, then a chart may be made by mounting these bottles. In the sodium compounds, salt would be the starting point, next would come sodium bicarbonate, between would be written the equations for the preparation of sodium bicarbonate from salt. In the same way the preparation of baking powder, and sodium carbonate using sodium bicarbonate could be shown. This serves to unify the individual projects into one big class project.

The other method tried consists in making a list of ten to fifteen unrelated projects, such as photography, explosives, production and uses of alcohol (industrial, not domestic), Plaster of Paris and cement, etc. The chief advantage of this lies in the

fact that the pupil's choice is more real, and his interest is therefore greater. This year, I expect to use both plans. The class has completed a set of projects in connection with chlorine, such as gas masks and gas warfare, bleaching powder, commercial preparation of chlorine, the preparation of other halogen elements, and another set dealing with sodium compounds. This has given them a chance to become more familiar with the use of equations, and to acquire more confidence in their ability to work independently. Their next assignment will be from the longer unrelated list of projects.

Most of the recitation time is used for the pupils' reports. The rest of the class takes notes on the reports as given, and answers a list of questions which the pupil conducting the class has made to cover the subject as he has presented it. From time to time, however, the teacher should take charge of a recitation for the purpose of relating the individual projects, and of bringing out the principles which have been illustrated by the work. For example, after the projects dealing with chlorine, bromine, and iodine, a recitation reviewing the chief characteristics of these elements and introducing the idea of the periodic arrangement is valuable in unifying the individual projects. The ideas of ionization and reversibility can be brought out by a recitation reviewing the preparation of the different sodium compounds. The theory of ionization has been used and explained by the pupil who studied the electrolytic preparation of chlorine. It should be pointed out to the pupils who are studying the Solvay Process, the reaction of baking powder, the making of caustic soda, that they are working with acids, bases and salts in solution, therefore with ions. With the completion of the calcium work, a comparison of formulae, as Na_2CO_3, $CaCO_3$, $NaOH$, $Ca(OH)_2$, introduces the idea of valence. This can be connected with the number of charges that an ion carries. The class can then be asked to learn the valence of the common elements and groups, and some drill can be given in writing formulae and balancing equations.

The grouping of projects, the review recitation, and the recitation presenting general principles growing out of the projects, are then ways in which we may unify the work, and in this manner make the reports of individuals valuable to the whole class. The other question that we need to consider is the amount and kind of guidance that should be given the pupil in his own project, in order that he may not waste time in ineffec-

tual work, and that he may develop initiative in solving his own problems in his own way.

In the small class, where the teacher can know what project each pupil is engaged in, and just how far he has progressed in it, the pupil can be left largely to his own initiative, with suggestions given by the teacher as the need arises. But in larger classes some guidance is necessary, as the teacher can not be everywhere, and answer every one's question at the psychological moment. A set of cards can be prepared for each project, giving a list of references and experiments. With this card as a starting point, the pupil can go ahead, but he should understand that the references given are simply a starting point, from which he is to develop his project according to his own ideas, adding other references and experiments as he works.

At present I am trying another plan, that of giving a set of leading questions, which indicate in general outline what the pupil needs to find out but leaving him to find information for himself wherever he can. The following set of questions is the one used on the project "nitric acid and explosives."

What is the general method of preparing an acid? Recall the method by which you prepared hydrogen chloride.
How could nitric acid be prepared in a similar way?
What property of hydrogen chloride enabled you to separate it from the sulphuric acid used?
Would it be possible to separate nitric and sulphuric acids in the same way?
What salt is used in preparing nitric acid? Is the quantity of this salt unlimited?
Prepare some nitric acid, and study its properties.
Make some gun cotton.
What is the theory of explosives?
Why is gun cotton a better explosive than Chinese gunpowder?
Why is sulphuric acid used in making guncotton?
What is dynamite? T. N. T.? What is celluloid? How does it resemble guncotton?
Could nitric acid be made starting with nitrogen?
What are the difficulties?
What is the Haber process?
Why did the government spend millions of dollars on the Mussels Shoals nitrate plant during the war?

Is this too much guidance? It may be. If the outline suggested in the questions is too slavishly followed, it may not leave any room for initiative on the part of the pupil. As the class which is using these outlines has not yet reported on the projects studied in this way, I am not prepared to say whether the outline is a help or hindrance. In working with large classes, we must be on our guard not to over-organize the method, and so lose its characteristic advantages. Before a pupil reports, it is well to have a short conference with him, in which he may outline the

way in which he is planning to present his material to the class. This gives the teacher a chance to suggest any changes in the order of presentation, which may make the work clearer to the other students, to correct any wrong ideas, and point out any gaps in the pupil's information. I think that an outline like the above on nitric acid, might serve better as a conclusion than as a starting point. After a student has worked out his project according to his own plan, such a list of questions would allow him to test his knowledge before he makes his final report but would not limit his project for him at the start. There is still much experimental work to be done before we find out how to give the right amount of guidance in the right way.

As to the results of this method, we have felt that there was more real interest and more genuine activity on the part of the class, when we were allowing them to work on their own projects. At the end of the year, I asked two classes to indicate their preference. I know that a class vote may be somewhat influenced by what the class thinks is the teacher's preference, so I tried to make it clear that I wanted their real opinion, that I did not care how the vote went. The vote stood 32-12 in favor of the project method. Pupils who have finished the course come back and tell us how much they enjoyed the work, and how well they remember and are able to apply the information gained in working on their projects. But you will say interest is not an accurate measure of accomplishment, and while the knowledge of the projects worked out may remain, do the pupils get enough out of the projects reported to them by other members of the class to have as wide range of information, as they would obtain from doing each experiment for themselves? Mr. S. R. Power's tests have given us some accurate information on this point. I

	Test I	Test II	Test III	Intelligence	
A	50.13	30.5	15.97	89.8	project.
B	45.8	29.7	17.21	68	project.
C	40.47	32	16.8	85	
D	42.1	30.5	18.3	85	
E	40.1	26	15.8	80	
F	40.2	27	15.2	77	
G	39.9	31.4	20.4	86.5	project.

have the results of the three chemistry tests and the intelligence test for all of the Chemistry IIs (second semester classes) in the department last June.

Test 1 covered mainly the writing of formulae, the naming of formulae, the completion and balancing of equations, and the writing of equations for familiar laboratory reactions. On this test two project-taught classes averaged from 3-7 points above the non-project classes, and a third project class averaged slightly below. The average of the project-taught classes was 45.28 and that of the non-project classes was 40.82 on Test 1. Test two was the range of information test. Here the project-taught classes averaged 30.5, the non-project classes 28.9. I consider this a more important test, as the ability to manipulate equations depends on the emphasis and practice given directly, and is not a by-product of any method. Range of information as accurate and as extensive as possible is a more important aim of high school chemistry, and the tests show that the project classes excelled somewhat in this. Test 3 was designed to test the pupil's ability to solve a problem question involving the use of facts which he has learned in other connections. Perhaps this is the most important aim of any school subject, to give the pupil power in solving problems, using the subject matter of chemistry or any other subject to develop this ability. Certainly this is the hardest aim to accomplish in teaching. On test three the project classes averaged 17.16 as against 16.52 for the others. The intelligence average for the project classes was 74.8; the non-project classes had an average of 81.7. The test results with the seven classes indicate that the accomplishment of the project classes, measured by standard tests, was slightly better than that of the non-project classes, although the intelligence rating of the latter was almost 7 points higher.

On test 2, we were able to check the performance of different sections on questions which had been reported to them by pupils, as the project lists had not been the same in each section. On test 2 question 14 deals with Plaster of Paris. In the section which had had a report on Plaster of Paris, 15 answered the question correctly; in the other section which had not had that project there were 9 correct answers. The question on cellulose was answered correctly by 16 in the section that had had it as a project, and only by five in the other section. The question on blue prints received 15 correct answers from the section that had had a report on photography, and by five in the other class.

These results indicate that the pupils in a project class do get and retain information on the material which is reported to them by other pupils.

From the point of view of the teacher the project method has its advantages. It is more flexible, more easily experimented with so there is less danger of getting into a rut. One may hesitate to try out new material on a whole class, but it is very easy to add new projects to the list, to be retained or dropped as experience indicates. In this way the teacher is not constantly going over the same material, but can add new material that is pertinent to different locations or suggested by current events. In the formally organized course the pupils have not the interest that they have in these tasks of their own choosing. This interest, and the responsibility which they have for giving the result of their investigation to the rest of the class, furnish real motives, and result in purposeful activity that is very gratifying to the teacher. I am conducting my fourth class by the project method, and while I feel that there are still problems to be solved, and difficulties to be smoothed out, my experience has convinced me that the inherent advantages of the method are so great, that it will pay any teacher to incorporate some project work into his teaching.

SHOWING THE EARTH'S MOVEMENT.

It is commonly supposed that it is not possible to demonstrate the movement of the earth without elaborate apparatus. This is very far from being the case as a simple device will indicate the earth's motion.

In the first place select a room that is fairly free from vibration. Then obtain a good-sized bowl or tub a foot or more in diameter and rather deep and nearly fill it with water. Place this on the floor of the room in such a position that it need not be disturbed for some hours. Get some finely powdered resin and sprinkle a coating of this on the surface of the water. Any fine substance that would float and not be dissolved for some hours would do as well. Next secure a little coal dust and sprinkle some on the top of the resin doing this in a straight line from the center to the circumference. Carry this line up over the rim of the bowl, and make it broad enough to be clearly seen—say about an inch in width.

The bowl may now be left for several hours, at the end of which time it will be noticed that an interesting thing has happened. It will be seen that the line on the surface of the water has changed its position and that it no longer meets that which runs up over the rim of the bowl. As a matter of fact the black line on the surface of the water has swept around from east to west.

What has happened is this: The water in the bowl has stood still throughout the time which it has been left while the vessel itself has been carried around by the motion of the earth from west to east. Another way of putting it is that the earth has swung around through a considerable arc from west to east, leaving the water quite stationary.—[By S. *Leonard Bastin*, in *Scientific American*.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

706. *Prof. W. W. Beman, University of Michigan,* writes that the second solution of problem 706 may be found in *Olney's Elementary Geometry, University Edition,* and that the third solution is Heron's own demonstration which can be found in *Heath's Elements of Euclid,* Vol. II.

724. In the statement of this problem last month, the reference to point I was omitted. The problem is restated below as number 726.

SOLUTION OF PROBLEMS.

711. *Proposed by Norman Anning, Ann Arbor, Mich.* (See problem 699.)

Given $\triangle ABC$ and a point P inside. Let $x = \angle BPC$, $y = \angle CPA$, $z = \angle APB$. Prove that if N is the number of ways of choosing the angles A, B, C, then the number of ways of choosing x, y, z is

$$N[1-(A^2+B^2+C^2)/\pi^2].$$

Solution by the Proposer.

As the problem is stated, the *radian* is the unit of angle. For greater convenience choose two right angles as unit angle. The possible values of the numbers A, B, C, x, y, z, are subject to the following restrictions.

$$\begin{array}{ll} 0<A<x<1 & A+B+C = 1 \\ 0<B<y<1 & x+y+z = 2 \\ 0<C<z<1 & \end{array}$$

If we consider the numbers A, B, C as the coordinates of a point, there is a set of values of A, B, C corresponding to every point of the equilateral triangle whose vertices have the rectangular space coordinates: (1, 0, 0), (0, 1, 0), (0, 0, 1). After choosing A, B, C, the possible choices of x, y, z, correspond to the coordinates of points within a hexagon whose vertices are, in succession (A, 1−A, 1), (1−B, B, 1), (1, B, 1−B), (1, 1−C, C), (1−C, 1, C), (A, 1, 1−A).

The area of the hexagon bears to the area of the former the ratio $(1-A^2-B^2-C^2) : 1$, or, changing to radian measure $(\pi^2-A^2-B^2-C^2) : \pi^2$. This fraction, which may be shown to be positive and not greater than 2/3, measures the restriction which the choice of A, B, C, puts upon the choice of x, y, z.

The editor adds a paragraph to explain the idea upon which this solution is based: The numbers A, B, C, are considered as the coordinates of a point P′, and the restrictions on our choice of the numbers compel the point P′ to lie within a certain area whose boundaries are determined by the maximum and minimum values of A, B, C. Similarly the numbers x, y, z are treated as coordinates of a point P″ which must lie within a certain area, a hexagon in this case. By comparing the areas within which P′ and P″ must lie, we can see whether we have a greater or smaller choice for the one set of numbers than for the other set.

712. *Proposed by Daniel Kreth, Wellman, Iowa.*

Construct the triangle, given the base a, the difference of the two adjacent angles, and the median to the given base.

No solution of this problem has been received.

713. *Proposed by Morris Monsky, Brooklyn Boys' High School, New York.*

A harmonic and an arithmetic progression have the same pth, qth, and rth terms, a, b, and c respectively. Prove

$$a(b-c)\log a+b(c-a)\log b+c(a-b)\log c = 0.$$

Solution by T. E. N. Eaton, Redlands H. S., California.

In the arithmetic progression, $c-b = b-a$. And in the geometric progression $1/c-1/b = 1/b-1/a$. Dividing the second equation by the first, $(b-c)/(c^2-b^2) = (a-b)/(b^2-a^2)$. In this equation, divide the first fraction by $c-b$, and the second fraction by $b-a$; then $a+b = c+b$ or $a = c$.

Hence these progressions are simply a succession of identical terms which really do not form a progression at all but do satisfy the *Proposer's* equation and a great many other equations involving zeros. I may be criticized for dividing by $c-b$ and $b-a$ which are zero; but if they are not zero, then the division is allowed; and when they approach zero the division is allowed, and is therefore true at the limit, thus proving the absurdity that if a, b, and c are not equal, then they are equal.

Also solved by *Michael Goldberg, Philadelphia, Pa.*

714. *Proposed by C. E. Githens, Wheeling, West Virginia.*

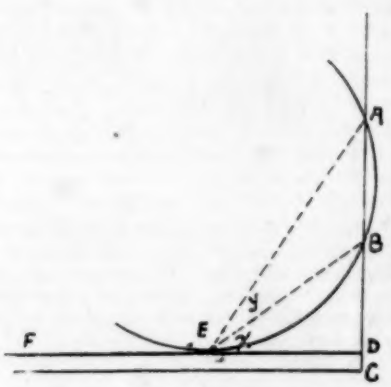
A statue thirty feet in height stands on a base twenty-nine feet high, both vertical to a plane. How many feet from the foot of the base is subtended the greatest vertical angle by the statue, the height of the eyes being five feet vertically above the level plane? Also, what is the tangent of the angle thus subtended? (Not to be solved by calculus.)

Solution by W. T. Harlon, Portland, Oregon.

In the figure AB = 30, BD = 24, DC = 5. DF is perpendicular to AC or parallel to the horizontal plane. Draw a circle through A and B, making it tangent to DF. Then the maximum visual angle will be at the point of contact E. Since $\angle$BED = $\angle$EAD, triangles BED and AED are similar, and ED/24 = 54/ED, or ED = 36.

Then $\tan x = 2/3$, $\tan(x+y) = 3/2$. Substituting these values in the formula for the sum of two angles, we find $\tan y = 5/12$.

Also solved by *Michael Goldberg, H. L. Wood, Boonton, N. J.*, and the *Proposer.*



715. *For high school students. Proposed by Norman Anning, Ann Arbor, Mich.*

Solve the equations: (1) $x+y^2 = 3$, (2) $x^2+y = 3$.

Three solutions are given below exactly as received, without the omission of even a comma, as it may be of interest to see how our work is arranged and explained.

I. *Solution by Theodore S. Kimball, Nashua H. S., N. H.*

By subtracting one from the other and factoring, we get

$(x-y)(x+y-1) = 0.$

(1) $x = y$

(2) $x = 1-y$

By substituting (1) in either equation and using quadratic formula we get, $y = \frac{-1\pm\sqrt{13}}{2}$. As $x = y$, $x = \frac{-1\pm\sqrt{13}}{2}$

By substituting (2) in either equation and factoring we get;

$(y-2)(y+1) = 0.$

Whence $y = 2$ or -1 and $x = -1$ or 2.

II. *Solution by Richard Cumming, Dalkeith, Scotland.*

From equation (1) we get $x = 3-y^2$. Substitute this value for x in equation (2), then $(3-y^2)^2 + y = 3$.

Squaring out and arranging we get $y^4-6y^2+y+6 = 0$.

Resolving into factors, $(y^2+y-3)(y^2-y-2) = 0$.

Therefore, $y^2+y-3 = 0$, or $y^2-y-2 = 0$

Therefore, $y = \frac{-1\pm\sqrt{13}}{2}$, or $y = 2$ or -1.

If $y = \frac{-1+\sqrt{13}}{2}$, then $x = 3-\left(\frac{-1+\sqrt{13}}{2}\right)^2 = \frac{-1+\sqrt{13}}{2}$

If $y = \frac{-1-\sqrt{13}}{2}$, then $x = 3-\left(\frac{-1-\sqrt{13}}{2}\right)^2 = \frac{-1-\sqrt{13}}{2}$

If $y = 2$, then $x = -1$, or if $y = -1$, then $x = 2$.

III. *Solution by Fannie C. Roll, North East H. S., Kansas City, Mo.*

(1)	$x^2+y = 3$	
(2)	$x+y^2 = 3$	
(3)	$x^2+y-x-y^2 = 0$	Subt. (2) from (1).
(4)	$x^2-y^2 = x-y$	Trans. (3).
(5)	$(x+y)(x-y) = (x-y)$	Factor (3)
(6)	$x+y = 1$	Divide by $x-y$
(7)	$x = 1-y$	Trans. (6)
(8)	$y^2-2y+1+y = 3$	Subst. $1-y$ for x in (1)
(9)	$y^2-y-2 = 0$	Trans. and com. (8)
(10)	$(y-2)(y+1) = 0$	Factoring (9)
(11)	$y = 2$	Trans. to get value of y
(12)	$y = -1$	Trans. to get value of y
(13)	$x = 1-2 = -1$	Subst. for y in (7)
(14)	$x = 1-(-1) = 2$	Subst. for y in (7)
(15)	$1+2 = 3$	Subst. numerical values in (1)
(16)	$2+1 = 3$	Subst. numerical values in (2)
(17)	$4-1 = 3$	Subst. numerical values in (1)
(18)	$2+1 = 3$	Subst. numerical values in (2)

Also solved by *Martin B. Dickinson*, and *Dorsey M. Osborne, Northeast H. S., Kansas City, Mo.; Edward M. Lewis, Redlands H. S., Calif.; Louis Sklar, Drexel Institute, Philadelphia.* It is seen that the third solution above omits the irrational solutions. Each of these solutions has some very good things in it; and the editor intends to have them copied on the blackboard and then allow the class to criticize them. Since they are solutions by pupils from other schools, the class will be interested in seeing how other pupils are working.

PROBLEMS FOR SOLUTION.

726. *Proposed by F. A. Cadwell, St. Paul, Minnesota.*

Three lines drawn from the vertices of a triangle ABC meet at a point O, either within or outside the triangle; AO, BO, and CO intersect BC, AC, and AB respectively at H, F, and G. A perpendicular drawn from H to FG meets FG at I. Prove (1) HI bisects $\angle$BIC, if F and G are

points on AC and AB unproduced, or if on AC and AB produced; (2) FI bisects $\angle BIC$ if F is on AC unproduced while G is a point on AB produced.

727. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn.*

The following is *Buonfalce's* method of approximating $\sqrt[3]{2}$. Find how close an approximation it is.

Construct a unit square ABCD on the line AB. With C as a center and CB as a radius draw the quadrant BD intersecting the diagonal AC in K. From B towards A, lay off $BE = AK/2$; and on CA lay off $CF = BC/4$. Join F to E, cutting the arc in point G. Then DG is approximately $\sqrt[3]{2}$.

728. *Proposed by Norman Anning, Ann Arbor, Mich.*

Prove: If x to the power 2^3 is equal to 2 to the power x^2, then either is equal to $6x^2-8$.

729. *Proposed by Arthur H. Lord, Lynn, Mass.*

Ten hours after a man had started on a trip a second man followed, gaining 3 miles every hour on the first. When he had been gone 8 hours, he met an expressman traveling at the same rate as he was, who said he had passed the first man 2 hours 24 minutes before. How long did it take the second man to overtake the first?

730. *For high school students. Proposed by the Editor.*

If AD is the altitude and AE the bisector of the $\angle BAC$ of the $\triangle BAC$, prove $\angle DAE = (\angle B - \angle C)/2$.

The object is not merely to find *a* proof but a *good* proof; and not merely to find a *proof* but also to have a good *presentation*.

NEW SERIES OF CHARTS ON FOOD SELECTION FOR TEACHERS OF NUTRITION.

Teachers and others carrying on nutrition work may obtain a new set of eight charts on food selection and meal planning prepared by the Office of Home Economics of the United States Department of Agriculture. They constitute a comprehensive and useful guide to a wise, correct diet.

One chart gives an explanation of the five food groups, and why each is needed. As a balanced food supply throughout a week insures a balanced diet, the proportion and amount of each kind of food which should be purchased for the average family is indicated. Each group is illustrated on a separate chart by a picture of selected foods from that group.

In order to facilitate the choice of foods according to the nutrients they contain there is a chart showing a great many common articles of diet, the unit of measure—pound, bushel, quart—by which each is usually bought, and the number of hundred-calorie portions contained in this unit of measure. Thus, the housekeeper can tell at a glance when the foods in the same group are the same price, which one yields the larger number of hundred-calorie portions for the money expended; or she can compute the cost of a hundred-calorie portion of any given food and compare that with the price of the food she desires to use.

The five pictorial charts showing a week's supply of each kind of food are based on the needs of the average family, consisting of two parents and three children. There is an additional chart showing how to compare one's own family with the average in order to arrive at a correct estimate of the amount of food to buy.

These charts should be found useful in connection with dietetic courses in colleges, high schools or hospitals, in women's clubs, parent-teacher associations, or wherever a thoughtful study of nutrition is being made. The charts are clearly printed on heavy paper 24 by 18 inches in size, and the series of eight can be obtained by sending 50 cents in cash or money order (no stamps) to the Superintendent of Documents, Washington, D. C.

SCIENCE AND SOAP—LAUNDRIES' HOPE.

Chemistry Gives Aid in Perfecting Cleansing Materials and Also in Instructing Washroom Workers.

How science is sparing clothes and improving soap was told by Dr. Martin H. Fischer in an address before the Cleveland Section of the American Chemical Society. His remarks were one of the signs of the coming of chemical control into the laundry. Only recently another member of the Society started a school where the employee of modern steam laundries is inducted into the mysteries of soap and soda and other compounds.

"While the soap water with which the housewife or laundryman washes soiled clothes is usually considered as a solution of soap in water," said Dr. Fischer, "it is not this solution which does the washing but a mixture of water dissolved in soap. Such hydrated soap, as it is called, may be either liquid or solid according to the temperature at which it is used. It is only when it is in the liquid condition that it will wash best. For this reason, a compound of sodium and oils, sodium oleate, which constitutes a large part of most of the ordinary toilet soaps, is one of the best of cleansers, even in cold water.

"It is, however, difficult to get this soap into cake form and so the manufacturer mixes it with more solid soaps like the palmitates and stearates. This yields a more solid bar, but also a soap mixture which does not take up water so readily at ordinary temperatures, that is, such a product does not so easily yield a liquid hydrated soap. For this reason, such soaps must be used in hot water. By using the stearates the soap manufacturer not only gives a more solid bar, but he also obtains a soap which in the cake will hold more water. That is, he can offer for sale less actual soap and more water, which means a cake which looks larger but is less effective as a washing agent."

In the opinion of Dr. Fischer, the laundering of the future will be done on a strictly scientific basis, and soap will be chosen with reference to the temperature at which it is to be used.

"The commercial soaps employed at the present time," he added, "are blunderbuss mixtures containing larger or smaller fractions of all these different soaps. This makes it possible to use common toilet and laundry soap in a wide variety of circumstances, though, of course, not with economy."

Some of the yellow laundry soaps are faulty, because when used with very hot water they set free resin and alkali. The rosin settles in the clothes and tends to make the fibre of woolen "mat," while the alkali eats the clothes. Woolens washed in this way are likely to become hard and stiff. Blankets and woolen garments, therefore, should be washed with soaps which do not suffer such decomposition and are soluble in water which is not too hot. When the garments are rinsed, therefore, soap of this kind readily leaves them.

In this connection, the founding of a course in laundry chemistry under the direction of Mr. E. P. Holder, a graduate of Yale University and a member of the American Chemical Society, is also of interest. It has been established at the Washington Irving High School, New York City, under the auspices of the Laundry and Allied Industries Board of Trade of Greater New York, Inc. The main object of the course is to teach the proper use of those materials employed in the cleansing of clothes and to avoid damage to the goods.

One of the sessions is devoted almost entirely to that great solvent, water. The laundry student learns the cause of hardness, is drilled in the

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temperature changes due to seasons, and is taught how he may soften and temper water H_2O to the most delicate fabric.

Often the fading of dyes, which has been falsely attributed to errors in manufacture, may be traced to excessive use of improperly prepared washing materials. The laundry industry in this course is giving its employees thorough instruction in the nature of dyes and colors, and gives special attention to the proper handling of fabrics which have been colored with direct dyes, mordant dyes, vat dyes, sulphur dyes, and anilines. There is also a lesson in blueing.

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NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

REPORT OF THE SEVENTY-FOURTH MEETING, AT MERIDEN, CONNECTICUT.

The second regional meeting of the Connecticut Valley Division of the New England Association of Chemistry Teachers was held at the Meriden High School on December 10, 1921. The meeting was well attended and enthusiastic.

A trip through the International Plating Company in the morning gave the members an opportunity to observe the stamping, spinning and casting of a large variety of metallic articles for jewelry and tableware, and the subsequent soldering, plating and burnishing operations.

Dinner was served and a social hour enjoyed at the Hotel Winthrop.

The afternoon meeting at the Meriden High School was presided over by Division Chairman Leslie O. Johnson of the New Haven High School. The President of the Association, Charles H. Stone, of Boston, brought greetings and congratulations from the central organization and gave the promise of the fullest cooperation with and the heartiest support of the future activities of this division.

Secretary Hoyt outlined the growth of the Association, which now numbers nearly four hundred science teachers, including nearly eighty college and normal school teachers of chemistry.

Professor Charles Ruglas Hoover, of Wesleyan University, gave an interesting address on "Some Recent Advances in Chemistry," using illustrative charts and models of atomic structure.

Committee reports on Apparatus and Current Events in Chemistry were made by Professor Hoover, Principal O'Neill of Derby, Professor Hill, of Wesleyan University, and Mr. Henry Stoddard Johnson, of New Haven.

A committee will soon begin work in collecting and arranging a series of "Standard Tests" in Chemistry.

A survey of the text-books in use at the various schools and colleges represented at the meeting was made.

Two films, one on the manufacture of soap and the other on the formation of crystals, were shown.

Twenty new members were admitted to the Association.

This live division proposes to hold another meeting in Springfield in March.

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"School Science and Mathematics" bears the same relation to progressive Science and Mathematics Teaching as does the "Iron Age" to the Hardware business. No up-to-date Hardware merchant does without this trade Journal. Every Science and Mathematics teacher should be a subscriber to the professional trade Journal, "School Science and Mathematics."

The motion picture camera is made in imitation of the eye. The better the condition of the lens and the better the illumination of the object, the better the result of the photographers effort. Just so with the more perfect instrument, the eye. It behooves every one to see that his eyes are kept in good condition and free from eye-strain coming from defects which may be corrected by glasses, or the strain due to improper lighting.

Save and Prolong Usefulness of Eyes.

A well-known specialist addressing a national conference stated: "For every blind person we generally can count from one to three who are what is termed near-blind, and a still greater number with markedly deficient vision. So we may continue to estimate until we come to what seems an almost universal lack of eye perfection.

"We shall better understand by the number of young men between the ages of twenty-one and thirty-one years who were refused entrance to the army because of deficient vision—so deficient that the glasses failed to bring it up even sufficiently for one draftee to be acceptable for limited service.

"Just as it is necessary for school children to be examined, so every individual between the ages of twenty-one and thirty-nine years should have the ocular state ascertained, as was done in the case of the army draftees.

"Early tendency toward the development of cataract may also occur during this period. Refractive errors (defective vision) when corrected lessen this tendency. Correction of defective eyesight, therefore, is a stitch in time, for it will save and prolong the usefulness of the eye."

Two Hundred Children Given "New Eyes."

Out of 100,000 pupils in the New York public schools who fail to be promoted each year, 50,000 have defective eyesight, 25,000 are suffering the humiliation of being "left-backs" simply because they are desperately in need of glasses.

The Junior Red Cross has established a $5,000 fund to aid parents in buying glasses for their children. Already 200 children have been given "new eyes," according to a report issued by a local chapter of the Red Cross. The fund is self-sustaining, in that the children pay back the cost of their glasses on the installment plan.

Every child who evidently does not see well and every child who is cross-eyed should be examined at three or four years of age. Every child is entitled to an examination of the eyes before beginning school work, no matter what the age. The vision should be tested every year, whether glasses are worn or not, in order to discover any defects that may be developing or any increase in defects known to exist.

Save Your Eyesight.

Few of us care to keep our eyes closed. Drugging them is merely temporary relief. Blurred glasses are only "blinders." There is only one way by which defective eyes can be kept open to see everything that they are intended to see and still be enabled to function normally, entirely free from muscular and nervous strain, and that is by wearing correctly adapted glasses.

Don't use drugs such as belladonna to make your eyes shine. Don't buy glasses without first consulting a specialist. Don't read or work in a bad light. Bathing the closed eyes with cold water two or three times a day is a splendid tonic and can do no harm except in certain forms of inflamnation.

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THE new plan of production and distribution of the Ford Educational Library places visual instructions within easy reach of all communities. Suitable subjects are now ready for the schools and will be distributed direct to them.

Each school may now have a film library from which the subjects may be selected at the time when needed. The new plan costs less than the present rent and transportation of films.

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Visual instruction to function in education must be organized in each community. There are many ways to organize to obtain the advantages of the Ford Educational Library. One method that has been successful, where small schools are near together, is to form a Ford Educational Library Association, which purchases all of the Library subjects. This provides at small cost to all schools carefully organized material in modern visual instruction. It is easy for each school in the Association to raise the necessary funds by giving exhibits or special evening entertainments, charging a small admission.

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EACH new subject in the Ford Educational Library is five cents per foot, or $50 for each 1,000 foot reel. With each new subject bought, two used reels are sent on a long loan. The cost of the three reels is lower than renting.

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Before May, 1922, 20 new subjects will be ready. These will cover many subjects to be edited for public school pupils. Educational experts and teachers who have definite ideas concerning new volumes in the Ford Educational Library are urged to correspond with us, so we may provide material to aid their program in visual instruction.

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Readers of SCHOOL SCIENCE AND MATHEMATICS in France, Italy, Spain, Belguim, Norway and Denmark or other foreign countries are requested to send examination questions to the editor of this department. Please send the addresses of book sellers or examination boards from whom such questions might be obtained.

Request and Remarks.

The editor of this department will especially appreciate solutions to the problems numbered 384,385,386,387 in the list of *Problems in Physics* from Sweden. Even the noted physicist who recently lamented in the columns of *Science* the inability and unwillingness of the American student to solve, the American teacher to instruct in problems involving some clean-cut mathematical thinking ought to be satisfied with the Swedish students who solve such problems successfully. Mr. Lundberg states that his students do well on such an examination. In fact, he intimated that this list is rather easy.

The editor can not refrain from calling attention to the statement at the head of the paper, "*Fifth Day of Writing.*" Our students in schools in the United States, together with their parents (and teachers), would think our poor dears terribly imposed upon by an examination extending to a "fifth day."

Questions and Problems for Solution.

Contributed by Mr. John Lundberg, Göteborg, Sweden.

Translated by Mr. Carl R. Nilsson, Engineering Dept., The Warner & Swasey Co., Cleveland, O.

Problems in Physics.

Student-Examination, Sweden, V. T. 1921.

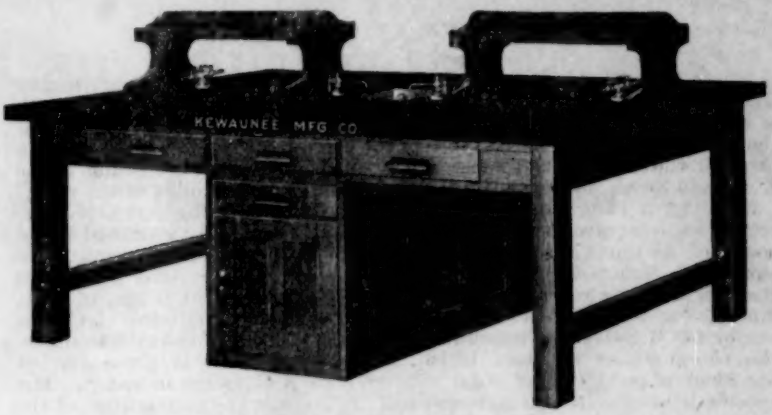
(*5:te skrivningsdagen.*)

384. A chain of length l is placed on an inclined plane and is in equilibrium. One part of the chain is resting on the plane while the remainder is allowed to hang freely over the edge. Give the longest and shortest part of the chain which rests on the plane. The angle of the plane with the horizontal is $V°$ and the coefficient of friction C.

385. To a glass ring of .893 gm. weight and 2.51 specific gravity is attached a strip of mineral whose weight is .528 gm. The whole is then placed in a liquid in which it sinks. By adding small portions of another heavier liquid which mixes with the first, the glass ring and strip of mineral are made to float. The specific gravity of the liquid is then found to be 3.18. Find the specific gravity of the mineral.

3. An organ pipe gives at 0° a certain tone. How much must the temperature rise in order to raise the tone one half tone. The speed of sound in air is proportional to the square root of the absolute temperature of the air. One-half tone is an interval of $^{1}/_{15}$. Absolute 0° is at —273° C. Temperature expansion of organ pipe not to be considered.

386. A glass ball, whose cubical coefficient of expansion is .000024 weighs in air 90 gm. If it is put into a certain liquid the temperature of which is 12° it weighs then 49.6 gm. If the liquid is heated to 97° the weight of the glass ball will be 51.9 gm. What is the coefficient of expansion of the liquid?



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5. In order to determine the refractive index of the glass in a concave convex lens one found the focal length to be 24 cm. and the focal length of concave surface, used as a mirror, to be 6 cm. Also the diameter of the lens was as well as the distance of the convex surface to a plane passing through the edge of the lens. These measurements were found to be 6 cm. and 8 cm. respectively. What is the refractive index of the glass?

387. In a calorimeter supplied with stirrer and thermometer (disregard water equivalent of calorimeter), is an electrically insulated metal spiral of 10 ohms resistance. When the thermometer registers 17° a current of .8 amperes is spent through the resistance. After 5 minutes the thermometer registers 18.1°. At this very moment 6 gm. of salammoniac at 17° is added to the water. In a couple of minutes the salt is completely dissolved. Five minutes after the addition of the salammoniac, the thermometer registers 18.16°. How much heat is given out or absorbed when 1 gm. of solid salammoniac is dissolved in water. The specific heat of solid salammoniac is .37. To raise the temperature of the solution a certain number of degrees can be considered to require the same amount of heat as if the sale remained undissolved in the pure water. 1 amp. through 1 ohm resistance develops .24 gram calories per second.

7. One has a battery of 5 galvanic calls connected in series, all exactly alike and with an E. M. F. of 1.33 volts each. By means of heavy copper wires, the resistance of which can be added, the poles of the battery are attached to a voltmeter which then shows a drop of 5.77 volts. If one of the cells is removed and a 100 ohm resistance is connected in series with the voltmeter, the instrument gives a drop of 2.95 volts. What is the internal resistance of each cell?

8. A glass half-sphere with a refractive index n is placed so that the flat surface just touches the surface of a liquid with the same refractive index, while the other part of the half sphere is in the air. In the liquid on the normal of the plane surface and passing through the center of the half sphere are 2 points, A and B, so located that all light rays passing through point A which go through the half sphere into the air refract in such a way that their extensions cut the normal at point B (B is also the virtual image of A). Determine the distance of these points from the surface of the liquid.

A certain inventor of a patented golf ball is said to draw $80,000 a year in royalties!!

The following problem is suggested by consideration of the above statement.

---

388. *Proposed by Al. Mears, Bond Department, The Union Trust Co., Cleveland, Ohio.*

Suppose we had three hollow aluminum balls. We create a vacuum in one, allow the internal pressure in another to be the same as outside atmospheric pressure, and into the third ball pump air (say 25 pounds pressure) and seal it up. Now use each for the center of three different golf balls.

Which ball would go farthest when hit equally with a golf club?

[*Query: Could the reader solve this problem if that eighty thousand depended upon it?*]

ANNOUNCEMENT OF THE SEVENTY-FIFTH MEETING MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

The seventy-fifth meeting of the Association will be held at the Massachusetts Institute of Technology on February 11, 1921.

Professor William T. Bovie, of the Harvard Medical School, will speak on some topic relating to the latest theories of the molecular structure of matter. Other features will make this meeting of profit alike to the college and the secondary school teacher of chemistry.—[S. Walter Hoyt, Secretary, 20 Stone Road, Belmont, Mass.

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CHILDREN CAN BE TAUGHT CORRECT DIET IN SCHOOL.

A campaign to improve the diet standards of children of school age was recently conducted in Akron, Ohio. As a preliminary step, 1,011 children were weighed and measured under the direction of school authorities. Of these children 58 per cent were underweight, nearly a fourth of these being more than 10 per cent underweight. On the suggestion of the home demonstration agent of the United States Department of Agriculture and state agricultural college the children were given one-half pint of milk in the middle of the morning, and the other underweight children were merely taught how to improve their weight themselves. At the close of the second month it was found that 67 per cent of all the children underweight had made some gain.

At this time the agent met with the mothers of these children to demonstrate the results of improved diet and to explain how to plan balanced meals. In this demonstration 60 boys and girls who had the largest underweight percentages were selected for physical examinations, made by a physician in the presence of the parents. Each mother was told what the proper average weight for age and height is. She was given a health card on which to record her child's health habits for a week. The record was to show the number of hours of sleep daily and a complete diet list, which was to be filled out and used according to instructions given by the home demonstration agent. Other health habits, such as deep breathing and teeth brushing were also to be recorded.

The demonstration was followed by weekly conferences of the mothers of the underweight children with the doctor, nurse, and home demonstration agent, at which the health record for the week was examined, the weekly weights taken, and additional instruction and advice given the parents. As a result almost every mother reported intelligent interest on the part of the children in the food work.

"We never sit down to the table, but that the question arises as to whether or not we are having the right things to eat," said one mother, in speaking of the excellent results achieved through this piece of nutrition work.

MEXICO.

"Mexico, so close that one is tempted to consider it a domestic rather than a foreign field, is nonetheless a country filled with people and customs strikingly foreign to those of the United States," says a bulletin issued from the Washington, D. C., headquarters of the National Geographic Society.

"And it is a country of contrasts. It is exceedingly rich in natural resources, yet a large part of its population lives in dire poverty. It had a university before John Harvard was born, yet the great mass of its people are illiterate. Modern equipages and machines are to be seen side by side with the most primitive vehicles and devices. And desert sands and tropical jungles can be found almost within a stone's throw of eternal snow.

Four Times the Area of France.

"The Mexico of today has an area of about 770,000 square miles—approximately a quarter that of the United States. Once the area of Mexico was two-thirds that of the big republic to the north. The difference is made up of territory (half that of the old Mexico) that has been transferred from Mexico to the United States—Texas, New Mexico, Arizona, Nevada, Utah, and parts of Wyoming, Colorado, Kansas and Oklahoma. Yet Mexico as it exists today is four times the size of France. Roughly, half of the long-shore line of the Gulf of Mexico is Mexican; and

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its Pacific coast is nearly a thousand miles longer than that of the United States exclusive of Alaska.

"But though Mexico has an area of great extent, what may be called the real Mexico is much smaller. Throughout the history of Mexico, both before the coming of the Spanish conquerors and since, the culture of the country and its center of population have been on the great central plateau which rises between the two oceans, and particularly in the south central part of that region. A section there occupying not more than one-sixth of the country contains nearly two-thirds of the total population. This portion of the country, of which the Valley of Mexico and the City of Mexico are near the center, has a delightful climate. Blankets are used at night the year round, but seldom at any time of the year is an overcoat needed at midday.

"The northern portion of Mexico is largely occupied by deserts. The southern section is tropical—a country of steamy moisture and jungles. Both coasts are hot and unpleasant throughout a large part of their extent. It is natural enough, therefore, that the central plateau has played an important part in the country's history.

FEW CITIES AND MANY VILLAGES.

"Mexico is essentially a rural country. Mexico City, the capital, with its million inhabitants, is the only city of large size within the country's borders. Between the metropolis and the next largest city, Guadalajara, is a great gulf, for the latter with its population of 120,000 is only the size of Nashville, Tenn., or Salt Lake City. Monterey, the greatest city of northern Mexico, and third in the country, is approximately the size of Harrisburg, El Paso, or San Diego. San Louis Potosi is the size of South Bend, Ind.; while Vera Cruz, the greatest port of the Republic and fifth city, is smaller than Tampa, Florida, or Charleston, S. C. Salina Cruz and the other Pacific ports are little more than villages with extensive docks. As a rule the cities of Mexico are not manufacturing centers but derive what importance they possess from being the markets for the surrounding agricultural country or mining regions.

"While Mexico is largely agricultural, and therefore rural, its country life is strikingly different from that with which farm-bred residents of the United States are familiar. Seldom is an isolated farmhouse to be found; most of the tillers of the soil live in little villages and go back and forth to their work, usually on the land of others. These innumerable villages give one the impression of being standardized and are difficult to tell apart. They are made up of low, rectangular flat-topped huts of mud bricks or adobe, and are huddled closely together. Between the forbidding walls of these tomb-like dwellings, the tropic sun beats down on a narrow, dusty street.

"In addition to these more or less independent villages of the common people there are to be found in parts of the country the haciendas or great ranches of the landed proprietors, on which are other groups of the inevitable flat-roofed huts, the dwellings of the ranch's peons. In the hot country of the South are extensive plantations of bananas, rubber trees, cacao and other special tropical products. These plantations are often operated by foreigners, and on them small armies of day laborers are employed.

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today less than 20 per cent of the inhabitants are pure whites, nearly one half are of mixed white and Indian blood, and the remainder are Indians. Many of the Indians and half-breeds constitute a sort of peasantry.

"It is estimated that about 7,000 of the 3,000,000 families of Mexico own all the tillable land. Since manufacturing enterprises and commercial pursuits are not sufficient to employ any great proportion of the inhabitants of the country, the great majority of the population must be jobless unless employed on the land of the relatively few landed proprietors. This landlessness of Mexico's masses and the lack of any appreciable middle class has been one of the principal causes of the many revolutions that have torn the country. Efforts have been made from time to time to reform the situation but with little success. The few peons who were given land following the Madero revolution had no training to make them appreciate the value of land ownership and independence. Most of the new land holders promptly sold their holdings cheaply and spent the money realized.

"Aboriginal traits cling to the mass of the Mexicans who are such a short distance in time removed from the strange mixture of barbarism and civilization that marked the empire of the Aztecs found by Cortez when he landed on the gulf coast in 1518—a civilization with its human sacrifices in a city carefully policed, and scrupulously kept clean by a corps of trained 'white-wings'; with its refined cannibalism beside an astronomical ability superior to that of the scholars who arranged the Julian calendar; with its institution of slavery the only one known in the world which provided that every child should be born a freeman. They are an artistic people, the Mexicans, apt musicians, modelers, basket-makers, featherworkers, weavers, and metal-workers.

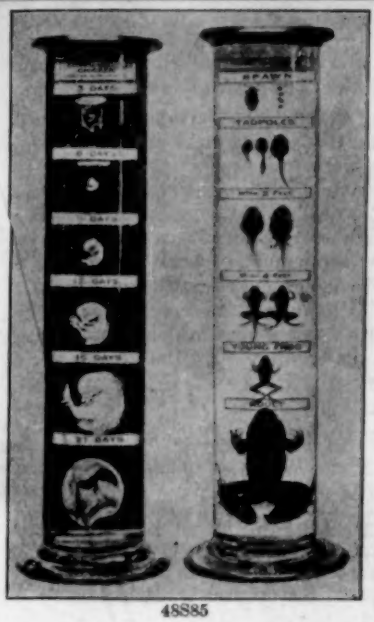
Graves Only Rented

"Poverty brings its tragedy into the deaths as well as into the lives of the masses of the Mexicans. Few are able to buy burial plots, and the custom of merely renting vaults for a short term of years has become general. The lease is often not renewed and the bones are cast on a heap of millions of others to make room for a time for some other unfortunate.

"Mexico abounds in holidays. Besides Sundays there is an equal number of saints' days and additional holy and feast days to bring the total to 131 of the 365.

"Mexico's large unassimilated Indian population and its even larger population in which Indian traits predominate makes a certain degree of turbulence a natural condition in the Republic south of the Rio Grande. The United States had not so long ago on its frontiers its Indian uprisings, its stage-coach and train robberies, and its 'bad men' with a penchant for 'shooting up' towns. Mexico is still in this stage of development, and because of the heavy Indian element in its population, probably will be there for many years.

"The government of Mexico is patterned after that of the United States, but in spirit the scheme has never been closely followed. From 1857, Mexico had one of the most liberal and advanced constitutions in existence, but it was largely a dead letter. In 1917 this constitution was replaced by one decidedly more radical, some of the provisions of which particularly affect missionary activities in the country. All religions were placed on the same footing by the document, but if it were enforced no religious organizations would be permitted to own property, even furnishings and utensils. All religious property was to be taken over by the state and merely left in the custody of churches by sufferance, under the control of the state.



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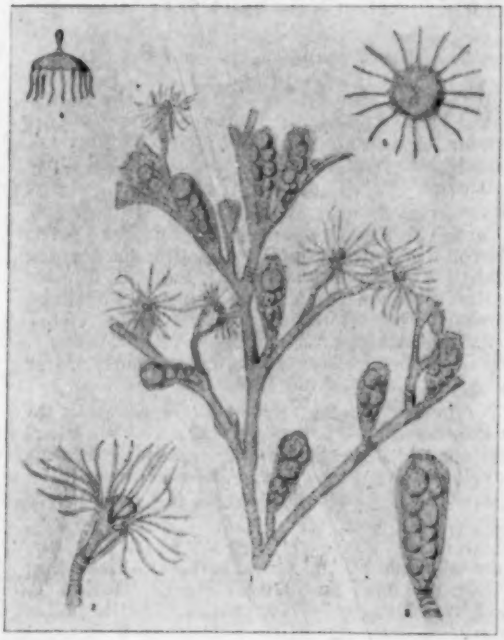

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"No religious organizations were to own or operate primary schools nor were ministers or priests to be allowed to teach in such institutions. Only Mexican-born ministers and priests were to be permitted to carry on religious activities, and the states were to limit the number of such ministers and priests and their churches. The taking of monastic vows was prohibited on the ground that the state cannot permit an agreement which curtails the liberty of men whether for purposes of work, education or religion. Most of the provisions of Mexico's new constitution which would bear so heavily on mission activities have remained so far merely threats on paper, pending negotiations with foreign governments and the establishments of a settled policy within the country. In the meantime missionary activity continues much as heretofore."

ARTICLES IN CURRENT PERIODICALS.

Americans Journal of Botony, for October, *Brooklyn Botanic Garden*, $6.00 *per year*, 75 *cents a copy*. "The Vascular Anatomy of Hemitrimerous Seedlings of Phaseolus Vulgaris," J. Arthur Harris, Edmund W. Sinnott, John Y. Pennypacker and G. B. Durham; "The Effect upon Permeability of Polyvalent Cations in Combination with Polyvalent Anions," Oran L. Raber; "The Floral Anatomy of the Urticales," Albert R. Bechtel; "Genetic Evidence of Aberrant Chromosome Behavior in Maize Endosperm," R. A. Emerson.

American Mathematical Monthly, for August-September, *Lancaster, Penn.* $5.00 *per year*, 60 *cents a copy*. "The March Meeting of the Ohio Section," G. N. Armstrong; "New Information Respecting Robert Recorde," D. E. Smith; "On a Diophantine Problem," O. D. Kellogg; "Among My Autographs: 10. Delambre Aids in Freeing Spencer Stanhop. 11. Voltaire and Mathematics," D. E. Smith; "Questions and Discussions."

American Botanist, for November, *Joliet, Ill.*, $1.50 *per year*, 40 *cents a copy*. "Old Garden Flowers, Wayside Flowers," Adello Prescott; "Notes on Oregon Plants," R. V. Bradshaw; "Plant Names and Their Meaning," Willard N. Clate.

National Geographic Magazine, for December, *Washington, D. C.*, $4.00 *per year*, 50 *cents a copy*. "The Islands of the Pacific" (with 15 illustrations), J. P. Thomson; "Nauru, the Richest Island in the South Seas" (with 24 illustrations), Mrs. Roasmond Dobson Rhone; "Yap and Other Pacific Islands under Japanese Mandate," (with 35 illustrations), Junius B. Wood; "The Mystery of Easter Island" (with 15 illustrations), Mrs. Scoresby Routledge.

Nature-Study Review, for October, *Ithaca, N. Y.*, $1.50 *per year*, 20 *cents a copy*. "Nature Study and The Reading Lesson," M. R. VanCleve; "The Wise Wood Rats," Carroll DeWilton Scott; "A California Nature Study Class," E. E. Balcomb; "An Oriole's Lullaby," Anna E. Lucas; "A Bee's Eye View," Helen Lee Sherwood; "Nature Study in a College Woman's Club," Martha Mong; "The Arbutus," B. O. Gutler; "A Disease of Mulberry Fruit," J. J. Taubenhaus; "The Purple Cone Flower," J. A. Drushel; "Nature Study in Webster Groves," Anna A. Jones; "Mrs. Grasshopper Goes House Hunting," A. J. Stactepole.

Photo-Era Magazine, for November, *Boston, Mass.*, $2.50 *per year*, 25 *cents a copy*. "Selling Your Photographs," Frederick C. Davis; "A Pearl of the Pacific," Dr. J. Moir Dalzell; "Experiences in Stereoscopic Photography," A. Jupenlaz; "Development After Fixing," A. Streissler; "My First Photograph," Wm. H. Zerbe; "Photography in a Coal-Mine," Edwards W. Donaldson.

Popular Astronomy, for December, *Northfield, Minn.*, $4.00 *per year*, 50 *cents a copy*. "Diameters of Star Disks, Lines," W. H. Pickering; "The Graphical Representation of Giant and Dwarf Stars," Harlan T. Stetson· "The Glacial Period and Drayson's Hypothesis," (with plates

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310 East Bridge Street, Streator, Illinois.

XXVII and XXVIII), John Millis; "Twenty-Sixth Meeting of the American Astronomical Society," (continued); "With Fervent Heat," Charles N. Holmes.

Scientific Monthly, for December, *Garrison, N. Y.*, $5.00 *per year*, 50 *cents a copy.* "The Inbred Descendants of Charlemange: A Glance at the Scientific Side of Genealogy," Dr. David Starr Jordan; "Studies in Infant Psychology," Dr. John B. Watson and Rosalie Raner Watson; "An Introduction to Scientific Vagaries," Professor D. W. Hering; "The Government Laboratory and Industrial Research," Dr. George K. Burgess; "America's First Agricultural School," Dr. Neil E. Stevens; "The Researcher in Science," Professor Michael F. Guyer; "Fearsome Monsters of Early Days," Dr. Leon Augustus Hausman.

School Review, for November, *University of Chicago Press*, $2.50 *per year*, 25 *cents a copy.* "The Selective Principle in American Secondary Education," I, George S. Counts; "Junior-College Courses in 1920-21," II, Leonard V. Koos; "Where Test Scores and Teachers' Marks Disagree," Mary D. Lindsay and Ruth S. Gamsby; "A Study of Current Practice as to Parent-Teacher Associations," R. B. Parsons; "Teaching a Study-Habit," I, Ralph E. Carter.

BOOKS RECEIVED

Analytical Geometry, by Charles N. Schmall, New York City. Pages XI+338. 14×20 cm. Cloth. 1921. D. Van Nostrand Company, New York City.

The Elements of High School Mathematics, by John B. Hamilton, University of Tennessee, Herbert E. Buchanan, Tulane University, and George W. Myers, University of Chicago. 297 pages. 12×18 cm. Cloth. 1921. Scott, Foresman and Co., Chicago.

Elementary Algebraic Geometry, by George W. Myers, the University of Chicago. Pages 111. 12×18 cm. Cloth. 1921. Scott, Forseman and Co., Chicago.

Mathematics for Students of Agriculture, by Samuel E. Rasor, Ohio State University. Pages VIII+290. 13×19 cm. Cloth. 1921. The Macmillan Company, New York.

Biology, Charles Gramet, Stuyvesant High School, New York City. 96 pages. 15×21 cm. Paper. 1921. Globe Book Company, New York.

Loose Leaf Laboratory Manual, B. B. Bueling No. 1, 25 pages, .35 cents. No. 2, 50 pages, 45 cents. 21×27.5 cm. Paper. 1921. Bruce Publishing Co., Milwaukee, Wis.

Facilities for Foreign Students in American Colleges and Universities. Bulletin, No. 39, 1920, by Samuel P. Copen. 269 pages. 15×23 cm. Paper. Government Printing Office, Washington.

BOOK REVIEWS.

Loose Leaf Manuals, by B. B. Burling. No. 1 $.35, 25 pages. No. 2 $.45, 50 pages. Size, 21×27 cm Paper. Bruce Publishing Co., Milwaukee, Wis.

These books are unique in their detail. The first page of each sheet is given to the regulr data, such as name of experiemnts, name of student, purpose, and references; there is a blank space being reserved for drawings. Following is a table for the data. On the opposite page there is usually a place for the descriptive work of the experiment. There are scattered through the book many pages of cross section paper for graphs. A place is reserved, too, for the instructors' check. The paper is good and will ink finely. Instructors thinking of adopting a loose leaf manual cannot do better than to get in touch with the publishers.

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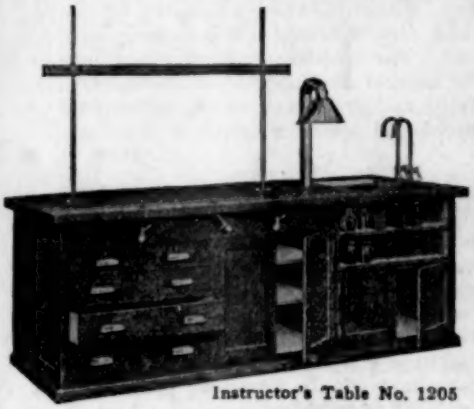

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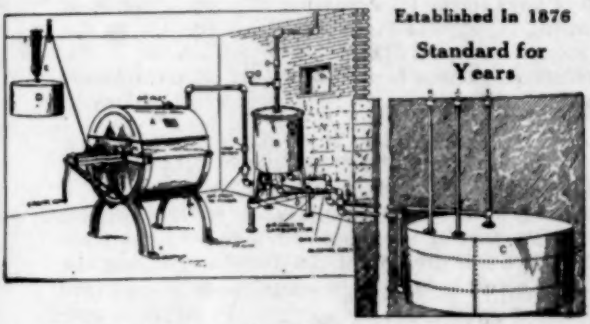

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Regents' Questions and Answers in Biology, by the Regents of the State of New York. Pages 111. 13×17 cm. Paper. 1921. Regents Publishing Co., 32 Union Square, N. Y. C.

This book is a compilation of the regents' questions given to the academies and high schools of the State of New York for several years back. It is up-to-date in every particular. Each question is followed by the answer, the answers being brief and clearly stated. Where necessary, drawings accompany the questions. The questions are classified into groups and each group follows the natural development of the subject. The questions can be used for review and drill work as well as on final examinations. All biology teachers should possess themselves of a copy.

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Wisconsin Reading Circle Annual. 67 pages. 15×23 cm. Paper. 1921. State Reading Circle Board, Madison, Wis.

This is a splendid little book gotten out for the purpose of guiding boys and girls, as well as older folk, into the habit of reading good books. The pamphlet will "foster patriotism by promoting good reading." Teachers can make splendid use of the book. It really is a hand book in their possession for promoting good reading. The book contains lists of good books together with the address of the publishers. It contains the names of many good books together with the groups of people who should become familiar with them. All English teachers who have to deal with good reading should possess themselves of a copy.

C. H. S.

Mechanical Drawing, First Year, by Ermeling, Fisher and Greene. Price, $.45. The Bruce Publishing Co., Milwaukee.

This book, by three of Chicago's better known drawing teachers, is a clear exposition of the subheads usually presented in the first year, that on isometric projection being especially good. This book is rich in material, thus allowing great latitude in choice of problems. R. W. W.

University of Illinois Bulletin, Report of the High School Visitor, by H. A. Hollister, University of Illinois. Pages 68; 15×23 cm. Paper. 1921. University of Illinois Press, Urbana, Ill.

This splendid report is gotten out by *The High School Visitor* and contains much valuable information. It discusses the financial side of the teaching profession very completely. Fine table of statistics being given from which valuable information can be secured. Much space is given to considering the ratio of boys to the total number of pupils enrolled in the high schools of Illinois. Complete statistics with reference to the accredited schools for the university of Illinois are given. A list of the accredited schools is also given. It is a book that should be in the hands of every high school teacher. C. H. S.

General Science, A Book of Projects by Edgar A. Bedford, Dewitt Clinton High School, N. Y. C. Pages XXIII+387+11. 13½×19 cm. Cloth. 1921. Allyn & Bacon, Chicago.

This is one of the best books of the kind which has come to the attention of the writer. No particular part of the sciences is treated more than the others. In fact, there is a fair division of the discussion among the various sciences treated. There has been an attempt made to cultivate a spirit of inquiry and open-mindedness. Also, to put the pupils in possession of certain fundamental truths which give an explanation of everyday life and to help the pupils learn a few of the forces and their effects which surround them. The projects have been selected largely

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from everyday phenomena. The illustrations have been selected with reference not only to their familiarity to the pupils but also for their value in bringing home many of the facts of nature. It is profusely illustrated with drawings in half-tones, of which there are 296, and which have been especially selected for this work. The projects begin with bold face type. It is splendidly written, the diction is fine, and put up in a way that the young pupil will understand. The type is printed in ten point type on splendid paper. It is a text which should be in the hands of every general science teacher. C. H. S.

Geography of Illinois, by D. C. Ridgley, Illinois State Normal University. 16 mo. 385 pages. 22 chapters and many illustrations. University of Chicago Press. 1921. $2.65.

Ridgley's Geography of Illinois will serve as a model for the development of similar studies in other states. In the modern text for elementary geography, the "state supplement" has reverted to the style of the gazeteer. The pupil finishes the elementary school too frequently, in ignorance of the simple facts of his own state and community. This text interests the citizen, stimulates the teacher and pupils. It is an authoritative geographical study of Illinois in compact and convenient form.

The geographical features, natural resources, and climate are clearly set forth. The response of people to these geographical influences are illustrated by the development of the different occupations.

The chapter upon weather and climate of Illinois, presents the climatic problems in clear statements, excellent pictures and graphs. This chapter is followed by one upon native vegetation which arouses the interest of those living in the Middle West.

The chapters on the natives and the coming of the white man unfold the familiar stages of conquest, hunter, pioneer, and permanent settlement. The rapidity of settlement is remarkable and the geographic influences which controlled the migration are clearly set forth.

The growth of transportation is presented in chapter four. The part of transportation in the development of a great state suggests a basis for civic lessons in good roads and available markets. As the land (transportation) occupation in Illinois has passed rapidly through different stages, so transportation of all kinds has undergone remarkable changes.

It has three hundred illustrations of maps, charts, graphs in black and white. Many of the important maps are splendidly colored to emphasize important details.

The excellence of this text will invite its wide use among teachers and pupils of geography. It should be followed by similar texts for other states. W. M. G.

Source Book for Economic Geography of North America, by C. C. Colby, University of Chicago. 8 vo. 410 pages. 14 chapters. University of Chicago Press. 1921. $4.15, postpaid.

This volume contains abundant material for the Economic Geography of North America. The abstracts have been selected by an expert and organized on a regional basis. Some of the selections which are given place in this volume are geographical classics and this text makes them easily available. Each broad region is introduced by a description of its geographical features, after which follows the agricultural, forestry, mining, and manufacturing industries. The compilation shows excellent judgment in selection of material and organization. The text is a necessary handbook for teachers of regional and commercial geography.

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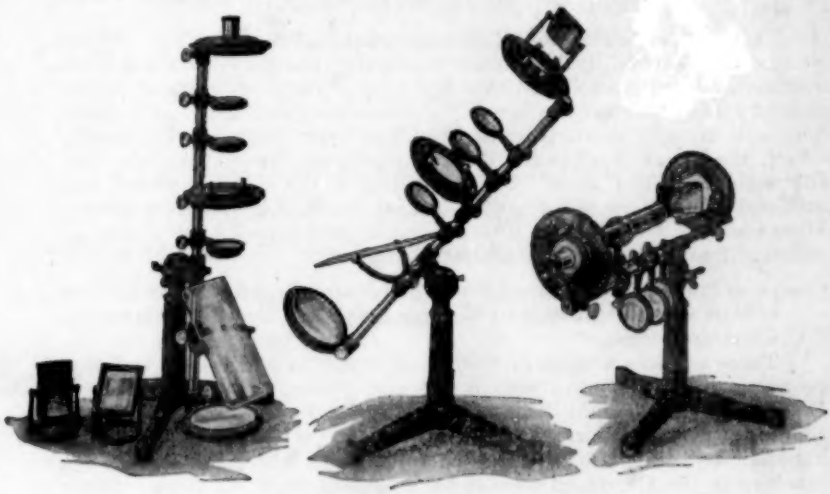

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Laboratory Projects in Physics, by Frederick F. Good, School of Education, Columbia University, New York City. Pages XIII plus 267. 13x19 cm. 1920. Cloth. The MacMillan Co., N. Y. C.

This is a book which shows considerable care and genius in its preparation. It is a departure from books of a similar character. There are 44 problems or projects discussed. The drawings are all practically new, they being made especially for this text. The author has gone into the home and taken many of his projects therefrom. It is written in a style that commends itself to the pupil and written so plainly that he would be obliged to understand. Major paragraphs begin in bold face type. Usually at the end of each project there is given a list of reference books. There is an appendix of text books to be consulted. There also is a complete list of the apparatus used in the book. The book deserves a large circulation and every general science teacher should possess himself of a copy. C. H. S.

Essentials of Physics, by George H. Hoadley, Swarthmore College. 544 pages. 13½x18½ cm. Cloth. 1921. $1.64. American Book Co., Chicago.

This is a revised edition of that splendid book by Hoadley. When we speak of revision in this case it means that the old edition has been overhauled to such an extent that one hardly would recognize it in the present edition, as there are so many new features introduced. The book has been brought down to date in almost every respect. Practically all of the latest mechanical devices, such as the automobile, are thoroughly touched upon. The mechanics of the moving-picture and artificial lighting are well treated. In fact, the book deserves the closest attention by all instructors who are thinking of introducing a new or different text. It deserves a wide circulation. C. H. S.

Courses of Study in the Cleveland Junior and Senior High Schools by teachers in these schools. From 8 to 66 pages. Paper. Board of Education, Cleveland, Ohio.

These outlines consist of courses of study in geography, in home economics, in hygiene, in art, in fine and applied art, in drawing, in English, and in manual or general science in the ninth grade. These courses represent the most recent outlines in the development of educational work in public high schools. Some of the more progressive teachers in the Cleveland schools have been at work on these outlines for a long time and they have produced something that is worth while. Many new and valuable features have been introduced although there is no radical change from those given anywhere in any large high school. Committees at work on new courses of study should provide themselves with these outlines as undoubtedly they will find much here which will help them solve some of their local problems. C. H. S.

Maryland School Bulletin, by the Department of Education. Pages 20 to 28, 15x23 cm. Paper. 1921. State Dept. of Education, Baltimore.

The pamphlets discussing the teaching of high school physics, the teaching of general science in high school, the teaching of high school biology, and the teaching of high school chemistry are surely well worth studying. These four outlines have been produced by various teachers in the Maryland Public Schools getting together and working out an outline for the teaching of these subjects which will be hard to duplicate. The matter is presented in such a form as to show that much study has been devoted to their preparation. It would be well worth while for all high school science teachers to possess themselves of copies of these bulletins. C. H. S.